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[*Frontispiece.*

A Carrara Marble Quarry.

MARBLE AND MARBLE WORKING

A HANDBOOK FOR ARCHITECTS, SCULPTORS, MARBLE QUARRY OWNERS AND WORKERS, AND ALL ENGAGED IN THE BUILDING AND DECORATIVE INDUSTRIES

BY

W. G. RENWICK

AUTHOR OF "THE MARBLE INDUSTRY," "THE WORKING OF MARBLE FOR DECORATIVE PURPOSES," ETC.

With Numerous Illustrations and Coloured Plates

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PREFACE.

NEARLY five years ago the writer was spending an evening in company with a member of the architectural profession and a mutual friend, who was engaged on the staff of a building trades journal, the time being passed in what is ordinarily known as "talking shop." The journalist had been taken to task for certain misstatements respecting marble and its working that had appeared in recent issues of his periodical, and for which he admitted responsibility, and the conversation ranged for some time on the use and abuse of marble for various purposes, and the difficulties experienced in obtaining information respecting the suitability of particular marbles for projected uses.

It was suggested that there was room for a handbook on marble, which, while not being abstruse, should yet be descriptive of the various types of marble and the processes the material went through from quarry to completed work; it should also contain a list of the principal marbles in ordinary use in the country, with a descriptive note of each variety, and, where possible, an accessible instance of its employment. This was the origin of the series of articles contributed to the pages of "The Quarry" during 1907–8, which, after considerable revision and additions, form the basis of the work now presented.

Thanks are due to Sir Archibald Geikie and Dr. G. P. Merrill, of the United States National Museum, and their respective publishers, for permission to use extracts from their copyright works having reference to the geology and chemistry of marble; and to Mr. Arthur Lee and Mr. William Brindley for similar permission in respect of its ancient working; also to the Council of the Royal Institute of British Architects for permission to use extracts from the Transactions and Journal of the Institute.

The marbles from which several of the colour repro ductions have been obtained were kindly supplied by Arthur Lee & Bros., Ltd., and White, Allom & Co., the samples having been selected by the writer as average quality material. Some of the colour blocks have also been loaned by firms interested in the respective marbles. The writer desires to express his obligations to M. Marcel Leclercq, the representative in the United Kingdom of La Société Anonyme de Merbes-le-Chateau, and Mr. R. O. Lamigeon, of Lamigeon & Co., Ltd., for information respecting the trade in Belgium and France; also to the many friends in the British Isles, on the Continent, and in the United States of America, who have kindly assisted with information; as well as to several of the leading firms, both of machinery manufacturers and quarry owners and workers, who have made offers of matter for illustration purposes.

The matter contained in the work is mainly derived from the personal experience and observation of the writer, who has been engaged in various capacities in the trade during the past twelve years. The leading establishments of Europe have been visited during this

period, and a practical acquaintance obtained of quarrying and working methods and appliances.

No apology is needed for the introduction of the work. Marble is perhaps the least known of all the materials employed in a building. Its literature is scanty and not up-to-date, the manner of its selection for use is haphazard rather than methodical, and, generally speaking, there are few building materials or accessories respecting which knowledge is less readily obtainable.

The writer has endeavoured to fill the void hitherto prevailing. If the results of his efforts are to check the use of marble in places where it is not likely to be of service, to indicate the more suitable qualities for particular purposes, and to encourage its employment where it may be used to advantage, the time spent in the preparation of the work will not have been wasted.

WM. G. RENWICK.

51, TREMAINE ROAD,
ANERLEY, S.E.

February, 1909.

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MARBLE AND MARBLE WORKING.

CHAPTER I.

Introductory—The Chemistry of Marble—Its Geological Formation—A Short Classification of Marble.

Over twenty years have elapsed since a work was produced dealing with the marbles used in Great Britain, and the methods adopted in their securing and working. The changes that have taken place during this period in every section of the industry have been so extensive in their range, and so far-reaching in their effect, that a review of their nature cannot fail to be of interest, and possibly will be instructive, to all who are interested either in the employment or working of the material.

The opportunity is a favourable one for taking a brief retrospect. During the period under review, new varieties of marble have come into use from Italy, Belgium, Sweden, France, Portugal, Canada, and the United States of America; the marbles of ancient Greece have been made available for use after a lapse of nearly twenty centuries; the Numidian marbles are again employed on an extensive scale, and, altogether, the range of material that is readily obtainable has been largely increased. The uses of marble have at the same time been considerably extended. Hotels and large business premises are nowadays considered incomplete without their marble halls; municipal, bank,

insurance, and general office buildings are similarly enriched; and entire erections, cased with marble from the basement to the chimneys, are not uncommon features of British twentieth century architecture. Whether the increased demand is causatory, or resultant to, the better facilities that are prevailing for obtaining and working the material is a matter for economists to settle; in either case it is correct to state that the processes—both of quarrying and working—have undergone changes as great, if not greater, than have occurred in any branch of the building and kindred trades. The introduction of the wire saw and penetrating pulley throughout Europe, and the improvements that have been made in channelling machinery in America, have greatly facilitated production, at the same time reducing the percentage of waste, thus making the quarrying of dimension stone both economical and profitable. Side by side with these improvements, new methods of working, involving the manufacture and employment of new types of machinery, have been introduced for fashioning the material, thus enabling work to be carried out in less time and with greater advantage to all concerned. Attention has at the same time been paid to the scientific side of marble production, and as our knowledge of the material and the conditions under which it was formed is increased, a better understanding prevails as to the uses for which it is capable, and the manner in which it can best be employed.

Few of the materials that go to the making up of a building are of greater interest, either to the student or worker, than the one under consideration. The durability of marble gives it an exceptional value as a means of perpetuating the best in architecture; its utility

in positions where cleanliness and high wearing qualities are required is without an equal; while for decorative effect, the infinite variety of its markings, combined with the taste that can be exercised in displaying and controlling the colour treatment, while adding to the architect's responsibility, gives greater scope to his individuality, and enables him to design and carry out effects that could not be secured by the employment of any other medium. The merchant is interested in securing for the architect new means of giving expression to his ideas, and the manufacturer is interested in giving effect to his designs; while the quarry owner is interested in endeavouring to fill the requirements of all three, and this in a material that differs in texture and marking with almost every block secured. From the stone lying in the quarry to the slab fixed on the wall of a building, every operation relating to marble is of interest.

The subject may be treated from many standpoints—the geologist, the chemist, the architect, the quarryman, the merchant, and the workman, each regarding the matter from his own point of view. While a treatise on marble from any one of these would appeal particularly to the individual, it is possible that a general survey of its formation, its quarrying, and its preparation, may contain something of interest to them all.

The term *marble* is one that is variously understood. From the scientist's standpoint only metamorphosed limestone should be included in its definition. Commercial men, however, are seldom scientists during business hours, especially if science interferes with their turnover; and although a strict interpretation may limit the term to crystalline calcareous and magnesian formations, so long

as architects and quantity surveyors include serpentines, breccias, travertines, alabaster, and sodalite in their specifications of marble work required, the manufacturer, knowing what is wanted, is prepared to fill the contract to the best of his ability, without troubling as to whether what he is supplying should or should not be termed marble. Hence, from a commercial standpoint, *marble* is recognised as including any natural stone that is of less hardness than granite, having a sufficiently close texture to take and retain a polished face, and being produced in such quantity as to be available for use for decorative purposes. The subject being here treated from a general point of view, the commercial, rather than the scientific, definition is adopted throughout.

The chemical composition of marble varies to a considerable extent.* With geologically marbles the fundamental element in practically all cases is calcium, which, in combination with carbon dioxide and oxygen, forms the mineral calcite ($CaCO_3$) = carbon dioxide 44 per cent., lime 56 per cent., or the rock limestone. Under the combined influences of heat and strain, limestone undergoes a gradual process known as *marmorosis*, which, while not materially affecting its chemical composition, results in the altered or metamorphosed rock becoming highly crystalline in structure, and possessing a greater density than that of the original.

An interesting instance of the occurrence of marmorosis can be traced in the lower beds of the limestone formation at Middleton-by-Wirksworth, in the lower Peak

* For fuller information respecting the chemistry of marbles, see "Stones for Building and Decoration," by G. P. Merrill, p. 18, etc.

district of Derbyshire. The outcrop, with the underlying strata, is of carboniferous age, and is traversed on its eastern boundary by a deep valley known as the "Gulf" (produced by a fault in the strata, a result of the straining incidental to Nature's process of mountain-making), exposing the face of the cliff. An examination of the cliff face discloses the presence of a layer of igneous rock, produced by a flow of lava during the carboniferous limestone period, and separating the formation into entirely different stones (see Fig. 1). Above the layer of intruded rock the limestone is common to the district — an unaltered mountain limestone. Below, the heat from the lava, extending downwards, has caused marmorosis to be set up, thus altering the entire structure of the rock and converting the limestone into marble. Both the unaltered and the metamorphous rock are of economic value. The materials from the upper layers, or mountain limestone beds, are used for lime burning, fluxing material, roadstone, etc., while the marmorised layers underlying the igneous intrusion form the Hopton-Wood stone of commerce. The metamorphosed rock or marble beds only occur below the lava outflow, which covers a comparatively small area, while the unaltered rock, or mountain limestone, is common to the entire Peak district.

No variety of marble is chemically pure. They all contain a greater or less amount of foreign material, sometimes chemically combined, sometimes as admixed minerals. The more common of these substances are carbonate of magnesia, the carbonates and oxides of iron, silica, clay, carbonaceous matter, mica, talc, and other minerals. It is the presence of these additions that gives to coloured marbles the veins, markings, and flowerings that make the

material of such availability for purposes of decoration. The various shades of yellow, pink, and red found in coloured marbles are mainly due to the iron oxides, the shades from bluish-grey to black are generally owing to the presence of carbonaceous matter, the greens are caused by the intrusion of iron and copper sulphides, mica, and talc.

Limestones which contain 10 per cent. and upwards of carbonate of magnesia are known as magnesian or dolomitic limestones. They may be crystalline in texture, showing all the variations common to ordinary limestones, from which they can only be distinguished by chemical tests. When the proportion of carbonate of magnesia displaces calcite to the extent of 45·65 per cent., the stone is known as dolomite. Many marbles are derived from magnesian limestones and dolomites, the chief distinction being the increased hardness and higher specific gravity of the latter. The specific gravity of best white marble (Carrara statuary) is 2·6 to 2·7, that of dolomite is 2·8 to 2·95.

Fossiliferous limestones may be either calcareous or dolomitic. The fossil remains are in some cases nearly perfect, in others they have been replaced by crystallised calcite. Crinoidal limestone is similar in formation, but is made up of fossil crinoid fragments. Several of our best-known marbles are derived from these varieties.

Many of the varieties of serpentine are considered as marbles, although their composition differs entirely from those heretofore considered. Serpentine consists mainly of the mineral serpentine—a hydrous silicate of magnesia ($Mg_3Si_2O_7 + 2H_2O$) = magnesia 43·48, silica 43·48, water 13·04. It occurs admixed with calcite and dolomite,

and is often found in extensive deposits. Many beds of serpentine result from olivine-bearing rocks. The greater number of green marbles are serpentinous.

The varieties of marble hitherto noted are metamorphosed rocks, *i.e.*, rocks that have undergone a change in their structure either from physical or chemical agencies. There are a number of marbles, commercially considered, that do not come within this description. The so-called onyx marbles or travertines are of two kinds, both consisting essentially of carbonate of lime. The one is a precipitation of lime from hot-water springs that has accumulated in natural basins, and the other a deposit of lime by the action of cold water on the roof, walls, and floor of limestone caves, the latter taking the form either of stalactites and stalagmites, or of pockets of marble formed in the rifts and cracks of the cave. The veinings and colourings are formed by metallic oxides.*

Alabaster is generally included in marble work specifications. It is a light cream, sometimes white variety of gypsum—calcium sulphate ($CaSo_4 + 2H_2O.$) = sulphur tri-oxide 46·5 per cent., lime 32·6 per cent., water 20·9 per cent. The varieties in general use for decorative purposes are veined and mottled.

The geologic occurrence of marble is of all ages from Silurian, in which is included the coral marbles of Devonshire and Staffordshire, through the Devonian, Carboniferous, and Permian periods of Paleozoic time down to the Triassic, Jurassic, and Cretaceous periods of Mesozoic time, in the latter of which the Istrian marbles and those of the Pas de Calais district are placed. Some of the

* See Arizona Onyx, pp. 98–9.

serpentines are derived from igneous rocks, and the travertines of Algeria are Quaternary, lying upon limestones of Tertiary (Middle Miocene) Age.

The saccharoidal varieties are caused by metamorphosis, due to intense heat and pressure, by which the original calcium carbonate has become crystallised.* Where the original rock was relatively pure, statuary marble was produced. In other cases, the presence of impurities gave rise to the various colourings and markings that add to the beauty of the material. The shrinkage of the mass in cooling sometimes caused cracks to form; these were afterwards filled either by the infiltration of metallic oxides, causing the darker varieties of veining, or by a leaching out of calcite from the impure rock, that afterwards crystallised, giving the white crystalline veinings and markings so often seen. Dr. G. P. Merrill, in his "Treatise on Rocks," etc., states: "The crystalline limestones and dolomites are but the metamorphosed sedimentary deposits described on p. 143 (The Calcareous Group of Aqueous Rocks). They occur associated with rocks of all ages, but only in regions that have been subjected to disturbances, such as the folding and faulting incident to mountain making, or the heat from intruded igneous rocks." . . . "The name *marble* is given to any calcareous or magnesian rock sufficiently beautiful to be utilised in decorative work."†

Breccias‡ are made up of angular fragments of older marbles, sometimes imbedded in a pasty magma, which

* See Geikie's "Text-book of Geology," 4th Edition (1903), pp. 192, 250.

† "Treatise on Rocks, Rock Weathering, and Soils," p. 163.

‡ See "Text-book of Geology," p. 164.

has crystallised on cooling, and sometimes split up into fragments by the pressure incidental to mountain making, and recemented by the infiltrations of calcite and metallic oxides. Breccias may be either calcareous, dolomitic, or serpentinous, or a combination of all three. They are of various ages and formations.

Serpentines are derived from older formations, sometimes of igneous rocks, sometimes of magnesian limestones, all of which have been entirely altered by chemical and physical action. They occur in all periods from Permian to Quaternary, and have at times a distinctly brecciated formation (see Verde Antico, p. 220).

The term "marble," from a commercial standpoint, may be taken as including limestones, magnesian limestones, and dolomites, onyx or travertines, serpentine, and alabaster—in short, all varieties of these stones capable of taking and retaining a polished face, and that are available for decorative purposes. In addition to these, there are various stones available for use for special purposes. Silicious pebbles, porphory, jasper, fluor spar (blue-john), lapis lazuli, sodalite, etc., are all of them used to some extent for decorative purposes, and come within the marble-worker's category.

The characteristics of marble vary to such an extent that classification, either on geological or chemical lines, would be practically impossible. All marbles, however, are possessed of features so pronounced as to admit of a division into easily recognised groups. These groups are ten in number:—

1. **Saccharoidal.**—This description applies to marbles that are even in grain and that present a sugary appearance on fracture. In this class are included the

finest statuary, the Italian white marbles known as Sicilian, Pentelikon, and the white marbles of Norway, Spain, and the United States of America. The least impure of these is statuary marble, the hardest-wearing is a variety of Sicilian having a bluish tinge. A distinctive feature of saccharoidal marbles is that the

FIG. 2.

SACCHAROIDAL MARBLE.
THE LOUNGE, HOTEL MAJESTIC, HARROGATE.

The Wall Lining is worked in Sicilian (Saccharoidal), with Griotte de Sost (Variegated) Bands, and Brêche Violette (Brecciated) Pilasters.

crystallisation is so regular that slabs can readily be coped to sizes required with hammer and chisel, other marbles requiring to be sawn. Saccharoidal marbles are very sound, and, when well selected, are available for use for exterior work as well as for the decoration of interiors.

2. **Unicoloured.**—This description applies to marbles without veinings or prominent markings, the colour tone being even throughout. The best-known varieties are Hopton-Wood (England), Comblanchien and Echaillon (France), Dove and Mazzano (Italy), Black (Belgium, etc.), Blue Pentelikon (Greece), and Blue Vermont (U.S.A.). Unicoloured marbles are most of them sound, are obtainable in large sizes, and are possessed of good weathering qualities. They are extensively used in conjunction with Sicilian marble for floors, and several of them may, when carefully selected, be used for building purposes.

3. **Variegated.**—This description applies to marbles in which patches and veinings of various colours are irregularly distributed. The veinings being in the majority of cases the result of the infiltration of metallic oxides and sulphides, a number of these varieties, when cut into slabs, are liable to fracture, the source of their beauty being a cause of weakness. Many of the red marbles in this class are "clayey" on the lines of veining. This defect necessitates the "raking out" of the defective portion and stopping with an artificial composition. Variegated marbles are found in all of the marble-producing countries. They are seldom suitable for other than purposes of interior decoration, and are seen to best advantage when used as linings to walls.

4. **Fossiliferous.**—This description applies to marbles containing fossil remains of various kinds. These are among the oldest of the rock formations from which marbles are secured, and the changes that have taken place in their construction have had a tendency to make certain of them unsound. This is particularly the case

with several of the red varieties, which are liable to exfoliation on exposure. The various shades of grey are closer in texture, and will resist atmospheric influences to

FIG. 3.

VARIEGATED MARBLE.

THE GRAND STAIRCASE, HOTEL RUSSELL, W.C.

The Columns and Architraves are of Campan Vert, the Pilasters and Handrail of Rosé du Var, on Griotte de Sost Pedestals, the Balustrading being of Siena, with Rosé du Var Base, and Sicilian (margins) Treads and Risers.

a greater extent than will the reds. Fossiliferous marbles are mainly found in Great Britain, Belgium, Brittany, and the north of France. Many of them are very beautiful,

and will take a high polish, but the greatest care must be exercised in their selection if durable results are to be secured.

5. **Crinoidal.**—This description applies to marbles made up of fossilised shell fragments. In some cases the shell formation is retained entire, in others it has been replaced by calcite crystals. Crinoidal marbles are fairly sound, but owing to the varying nature of the cementing medium, few of them are suited for use in exposed positions. Some of the crinoidal marbles are bituminous in character, this quality being derived from decomposed animal or vegetable matter present in the formation. This is apparent by the odour given off on fracture, also when tooling the material. Belgian "Granit," certain varieties of Bleu Belge, and some of the Derbyshire varieties, are subject to this peculiarity, which results in the surface becoming dulled, and presenting a greyish appearance under the polished face when used for exterior work. Crinoidal marbles are extensively distributed, and are in greater demand for Continental work than is the case in this country.

6. **Brecciated.**—This description applies to marbles made up of angular fragments of limestone of various colours, such fragments being pieces of older rocks crushed by physical agencies, and recemented into solid rock by the infiltration of lime and metallic oxides, or imbedded in a marble magma in process of cooling down. Some of the brecciated marbles are of great beauty. They are principally obtained from Italy and the French Pyrenees, and are extensively used in Great Britain, both for wall linings, etc., and in columnar form. Breccias are mostly sound, and are obtainable in large sizes. Pudding-stones

are of similar formation to breccias, but the fragments have been rounded, probably by the action of water prior to their recementation. Owing to their formation, the

FIG. 4.

BRECCIATED MARBLE.

THE GRAND CHIMNEY-PIECE, HOTEL RUSSELL, W.C.

The Breast, etc., is of Brêche Violette (Brecciated), with Statuary Panel and Trusses, the Moulded Frieze being of Campan Melangé, and Cornice of Rosé du Var.

pieces of which they are composed are apt to break loose from the magma in which they are embedded. Pudding-stones are not used to any large extent in this country.

Fig. 5.

LAMINATED MARBLE.

Under the Dome, New Sessions House, E.C.

The Architraves, Niches, and Friezes, etc., are of Greek Cippolino (Laminated), with Pavonazzo (Variegated) Panels and Spandrel Fillings.

7. **Laminated.**—This description applies to marbles the veining of which is more or less regular, the formation of the marble in its bed being indicated by bands of differing colour. The varieties of Cippolino belong to this class. The best of these are obtained from Greece, other varieties are quarried in Switzerland and Italy. Laminated marbles are best displayed in columnar form, but a handsome effect is secured by using slabs cut with the bed as panelling for large surfaces, also for heavy mouldings of plain section. The use of laminated marbles for decorative work is general throughout Europe.

8. **Travertines.**—This description applies to the varieties known as onyx marbles. Travertines have, when polished, a hard, glassy face, and are in many cases almost transparent. Some of the brighter-coloured varieties have what is known as "water veins," along which they fracture when given a slight tap. The best varieties are obtained from Brazil, Mexico, and Arizona, U.S.A., others from Algeria and Italy. The term "onyx," as applied to this class of marble, is a misnomer, true onyx being a variety of chalcedony (SiO_2). Travertines are in considerable demand for decorative purposes. They should be used sparingly, and are displayed to greatest advantage in conjunction with marbles of a complementary colour, but of less brilliancy. Stalagmitic and stalactitic formations are also known as onyx marble.

9. **Serpentinous.**—This description applies to marbles composed wholly or mainly of the mineral serpentine, and includes most of the varieties of dark green marbles. The principal supplies are obtained from Italy, the French Alps, Greece (Larissa and Tinos), and Ireland (Connemara). Serpentinous marbles are

extensively used for decorative purposes, both for columnar and facing work. They are sound in texture, and several of them can be procured in large sizes.

10. **Alabaster.***—This is the softest of all the stones used for decorative purposes. When carefully selected, it makes an effective wall decoration, either alone or in combination with other marbles. Alabaster is quarried extensively in England (principally in Staffordshire and Derbyshire), France, Germany, and Italy. The clear Italian variety is often substituted for statuary marble for low-priced carved ornaments (see pp. 74–5).

* Alabaster is not, strictly speaking, a marble, but is included on account of its extensive use, both for decorative purposes and, after preparation, as a cheap substitute for Carrara statuary. It can be distinguished from the latter by its greater softness, being readily scratched by any hard substance.

CHAPTER II.

Antiquity of the Marble Industry—Ancient Quarries and Methods of Working.

The quarrying and working of marble are among the earliest of the building and decorative crafts. While from the nature of the material but little remains of the work of remote ages, records are not lacking of its use in practically all the periods of the world's civilisation. Herodotus describes the Great Pyramid of Ghizeh as being cased with polished marble, which gave to the great pile an appearance of dazzling brightness. "Marble stones in abundance" is mentioned (1 Chron. xxix. 2), *circa* B.C. 1015, as included in the preparations made by David for the building of the Temple at Jerusalem. In the Vulgate and Septuagint versions of the Bible, it is stated that Parian marble was secured by David for the building of the Temple. If this is a correct rendering of the text, it proves that this marble was well known over a thousand years before the Christian Era. Josephus has placed it on record (Book viii., Sec. 3) that the body of the temple was built of white stone or marble, the cloisters being of native stone, all worked prior to being brought on the site, and fixed without sound of hammer. Mention is also made in the Book of Esther (Esther i. 6), *circa* B.C. 519, of "hangings . . . . fastened to silver rings and pillars of marble," and of "a pavement of red, and blue, and white, and black marble" in the palace of Shushan, the abode of King Ahasuerus. (The marginal notes to

the latter quotation give an alternative reading of "porphorie, and alabaster, and stone of blue colour.")

Marble was the medium for the greatest height of artistic expression, whether for sculpture or architecture, in ancient Greece. The buildings that yet remain at Athens, although in ruins—the Parthenon, the Erectheium, Propylæa, Theseium, Olympieium, etc., not to mention the ruins at Antioch, Ephesus, Miletus, Epidaurus, Bassæ, etc.—are instances of the expression of the highest artistic feeling, executed in the noblest of materials. Indeed, it is no exaggeration to state, that but for the lasting nature of the medium employed, the most magnificent conceptions, both in architecture and sculpture, would have been lost to the world. When it is remembered that the elevations of our noblest buildings are based on classic examples executed in marble (the only medium in which such preservation as has obtained was possible), the debt of modernity both to the medium and the workers therein of ancient times is indeed a heavy one. Nor is this the whole of the debt. Mr. W. Brindley has pointed out that the imperishable nature of the material has enabled records to be preserved which throw light on the history and civilisation of bygone ages. "Marble slabs are not worth stealing, as they cannot be put into the melting pot."..."We are indebted to incised marble slabs for most of our early records, which, had they been in metal plates, would doubtless have been lost to us." *

The marble for sculptured work was principally obtained from Mount Marpressa, near the centre of the

* Mr. W. Brindley: Transactions of Royal Institute of British Architects, New Series, Vol. III., p. 53.

island of Paros, in the Ægean Sea, and from thence the variety of Parian marble known as *Lychnites* (from its being quarried in the dark, *i.e.*, underground) was obtained. The Venus of Milo, the Venus de Medicis, and the Capitoline Venus are stated to be worked in this marble, as are the Apollo Belvedere and other world-famed examples of Grecian art. Marble for building purposes, also a selected variety for use for sculptured work, was obtained from Mount Pentelicus, some nine miles north-east of Athens. The deposits are of great extent, and have been reopened and developed during recent years on modern lines (see pp. 86–7).

The quarries of Luna, now Carrara (from the Latin *quarrariæ*, whence our English word quarry), were first worked by the Romans about B.C. 173. Marble had previously come into considerable demand, as the result of the spoils of the Macedonian war being brought home to Rome by the conquerors; and the discovery of a practically inexhaustible supply of the material within easy distance of Imperial Rome caused it to be extensively employed in the rebuilding of the city under the Emperor Augustus. Greek marble was also imported to a considerable extent, as is shown by the quantity of the material found in ancient Roman buildings. This is known to the Italian workmen as *Marmo Græco Fino.*

While mention is often made of Gibbon's statement respecting the Emperor Augustus, that "he found his capital of brick, but left it of marble," it is generally assumed that the Carrara variety, with some amount of imported Greek Pentelikon, were the only marbles used. This is not correct. Sir Edward Hull tells us that the Emperor Augustus selected Travertine, quarried at Tivoli, and the

product of the Luna quarries for the numerous buildings and restorations effected under his auspices, and that part of the Arch of the Cloaca Maxima and the entire exterior of the Colosseum, founded by Vespasian in the middle of the first century, were erected from the former; and that it was from this building (the Colosseum) that the stones for building the Palace of St. Mark's, Venice, the Cancellaria, and the Palazzo Farnese, were obtained at a later date.* The material, a straw-coloured onyx marble, has been in use right through the centuries that have since elapsed. It is employed for the external walls of nearly all the churches of Rome, including St. Peter's, the Museum and Church of the Lateran, the Castle of Saint Angelo, and portions of the city walls, and is in employment to this day.

It is interesting to note that the competition of bygone days between the principal marble-producing centres is being actively revived, and that although the Tivoli product has not attained the dignity of a leading article of export, the claims of Pentelikon marble over the Carrara variety are being vigorously urged.

Other deposits known to the ancients were the Cippolino marbles of Eubœa, Rosso Antico of Laconia and Damaristica, and Verde Antico of Thessaly, all of which have been rediscovered of recent years, and are now in extensive use. Mention may also be made of the deposits in Tunisia and Algeria, from which districts the ancient Numidian marbles (*Marmor Numidicum*) were obtained. In fact, it has been stated by Mr. W. Brindley that of the

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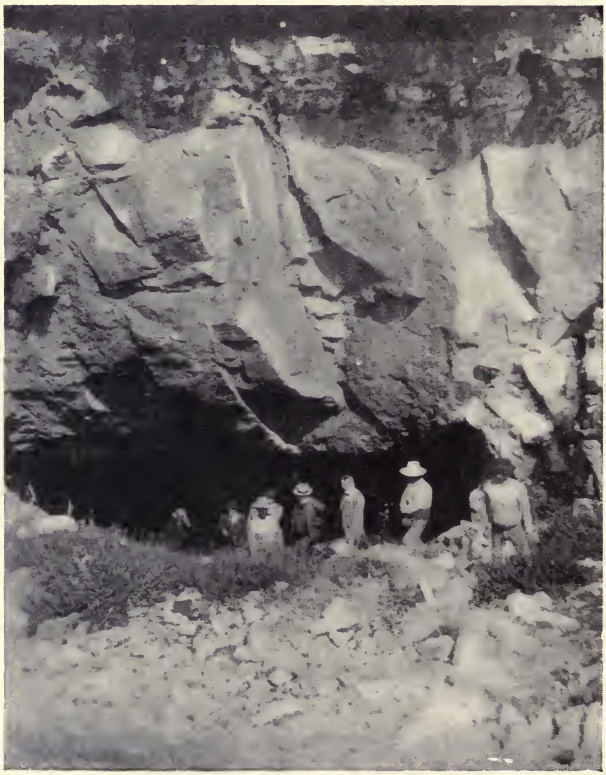
* See Hull's "Treatise on Building and Ornamental Stones," 1872, p. 280.

forty-two marbles known to the ancient Romans, all but two have been located, and are available if required for present-day use.

The methods adopted for the extraction of stone by the ancients are in many cases traceable from the old

FIG. 6.



ANCIENT MARBLE QUARRY, SKYROS, GRECIAN ARCHIPELAGO.

workings. Several of the ancient quarries on Mount Pentelicus are preserved for archæological reasons, and from these it is apparent that although the dip of the quarry inclined inwards from the working face, the blocks were removed by wedging on a horizontal plane, a

SKYROS No. 12 (GRECIAN ARCHIPELAGO).

[*To face p.* 22.

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perpendicular face having first been chiselled. Roughly squared blocks to required dimensions were thus easily secured. There are a number of micaceous seams in this formation running with the bed, and, from the method of extraction adopted, these traversed the blocks in a slanting direction. As the weather-resisting properties of the seams are much lower than that of the marble, some disintegration on the lines of the seams, apparent in many of the ancient buildings, occurred. In the modern workings of the Pentelic deposits, this defect has been remedied, the extraction of blocks now following the dip of the formation. The mica seams are fairly regular in their distribution, and where they are so pronounced as to probably interfere with the durability of the marble, are avoided.

Mention is made by Mr. Arthur Lee* that in the ancient workings in Algeria blocks of marble have been found actually extracted, and others with grooves and wedge holes ready to be raised. The wedges used were ordinarily of wood, and were driven into prepared holes and repeatedly moistened, the resultant swelling having the effect of bursting the marble from its bed. In some instances, bronze wedges are supposed to have been used.

An interesting method in force for the quarrying of columns, ensuring that the marble when *in situ* should occupy the same relative position in the building as in the quarry, is described by Mr. W. Brindley in his account of the workings at the ancient Verde Antico quarries near Larissa, Thessaly, rediscovered by him in 1889. He states: "One large quarry face consists of a series of vertical, almost semi-circular hollows, of varying large

* "Marble and Marble Workers," 1887, p. 90.

diameter; a mass in front of this shows smaller hollows—here, no doubt, were extracted the monolith columns of St. Sophia, Constantinople, the rough columnar form being rounded as quarried—these hollows being the matrices allowing room for the workman to axe round the columns, less at the back and more at the sides, where the quarryman would stand to work. The shafts would thus be produced standing free from the rock; they would then be severed at the base and lowered over by ropes and wedges, while the projection between the hollows would produce the next row of shafts." . . . "Another quarry contains a block of large dimensions squared up for a sarcophagus. This is still attached by the bottom bed to the solid rock, a passage being cut all round it. This block would make a sarcophagus similar to the three famous ones in Constantinople, one of which is in front of the Pantocrator Church, the other two near the Seraglio. Two or three of the workings have sawn faces, and sawn blocks and scantlings for slabs have the saw-cuts remaining below where they were wedged off. Everything seen in their methods of working points to the minimising of weight for transit."*

Another method adopted in early days was a combination of the principles of heat and strain. Fires lighted along a previously marked line would, after attaining a certain heat, be quenched simultaneously, the contraction occasioned by the sudden cooling causing rifts to occur in the formation. These were further widened by means of wedges and levers, until masses of stone became detached. This method is in force in India for the extraction of granite to the present day.

* Transactions of R.I.B.A., Series III., Vol. III., pp. 267–8.

CHAPTER III.

Modern Quarries and Quarrying Methods—Machinery Used in Quarrying—European and American Systems Compared.

THE quarries from which the marble used in the United Kingdom are supplied are situate in nearly every country in Europe. Of these, Italy is an easy first, followed by France, Belgium, and Greece. Portugal, Sweden, Austria, Spain, Switzerland, and Germany are all of them producers for the English market, but to a smaller extent than the first four named. A considerable amount, too, comes from North Africa (Tunisia and Algeria), from the district whence the Marmor Numidica of the Romans was obtained, and smaller quantities from the United States of America, Mexico, and Brazil. The importations from the two latter countries mainly consist of onyx marbles. A number of marbles are quarried in the British Isles, principally in Devonshire, Derbyshire, Cumberland, the Western Hebrides, and the south and west of Ireland.

The methods in force for the extraction of blocks vary to a considerable extent, some of them being very primitive in their nature. In a few districts explosives are used to extract the rock. This method is far from economical. It not only results in a large amount of waste being made, but, where employed for comparatively small blocks, has a tendency to disintegrate the stone, causing it to fall to pieces when sawn into slabs. The writer has in mind a Devonshire marble of good appearance. The quarry is worked for limestone, which is principally used

as road metal, but when a large block comes out, it is reserved for sale as marble. The use of explosives facilitates the breaking up of the stone for the main purposes for which it is used, but has a bad effect upon the large blocks. The result is that although the material is to all appearance a compact stone in the quarry, its reputation among marble workers is that of being very unsound. It may be taken, as a general rule, that with the possible exception of black marble, the use of explosives should not be resorted to for the extraction of blocks for use as marble, provided that other means of quarrying are available.

Where the more modern appliances are in use, the system adopted varies, sometimes in accordance with the formation of the deposit, but more often on account of the individual experience of the quarry manager as to appliances in use. Thus, a man who has been accustomed to extraction by a particular method will develop a property of which he has charge by the system he knows best. He will not introduce one with which he is unfamiliar, although it may be better suited to the formation he is exploiting. Quarry owners and managers are most conservative in their methods, the result being that the best means of extracting merchantable material are not always adopted. It is not an uncommon event for a marble property to be worked for a time by "rule of thumb" methods, the result being a choking up of merchantable rock with waste, and ultimately making the further working of the property unprofitable.

The methods adopted generally for the quarrying of marble are three in number—wedging, sawing, and channelling. Each method has points distinctly its own, and it is advisable for them to be separately described.

Wedging.—This method of extraction is the oldest, as well as the simplest, of any existing. No machinery of any kind is required, the marble being forced from its bed in the quarry by the action of steel wedges driven either between the veins or in rifts in the formation. The mode

FIG. 7.

WEDGING:—TROU DE VERSAILLES, RANCE, BELGIUM.
The ledges shown on the left are of seventeenth century workings.

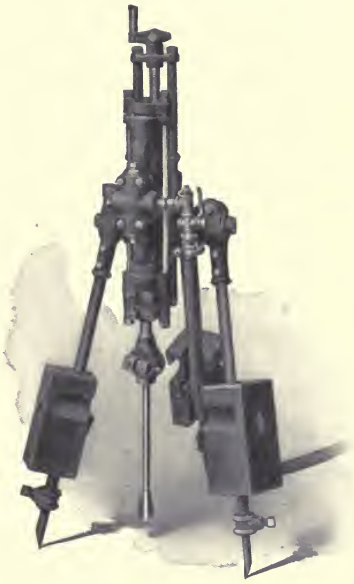
of procedure is most wasteful. It seldom happens that marble occurs in even layers, and where both veining and bedding are irregular, the blocks obtained are of all possible shapes, and have, after extraction, to be broken up into the required sizes and roughly squared. Under ordinary circumstances, the accumulations of *débris* cannot

be used to advantage, the result being that sooner or later the good beds are difficult of approach, and considerable amounts of payable stone are made inaccessible. Even where the conditions are favourable the percentage of waste is very high, and its reduction by the adoption of more modern methods would give satisfactory returns for the increased expenditure involved. Wedging is most in force in quarries that are worked on communal lines, and those situated in isolated positions, especially where the proper development of the deposits is retarded by lack of capital. It is only suitable for adoption where the deposits lie on or near the surface.

A combination of drill and wedge work is sometimes adopted for the extraction of marble. Two men are engaged in the process of hand drilling, the one holding the drill or jumper in position, while the other strikes the disengaged end with a heavy hammer, the drill being slightly turned at each stroke. The work, both of wedging and drilling, is of a heavy nature, and calls for the exercise of considerable discretion. It is not highly paid. The holes drilled vary from two-thirds to the full depth of the block required, and long metal wedges or plugs are inserted, which, on being tightened, burst the marble from its bed. In some cases holes to a depth of about 5 in. alternate with others of full depth of the block. Where the marble deposits are in comparatively shallow beds, the shorter holes are sufficient, the blocks being broken out with steel wedges driven between soft iron slips placed on the lip of each hole. This is known as plug and feather work. The method adopted depends on the nature of the stone, the lines of cleavage, and the general formation.

Machine Drills.—The process of drilling was formerly carried out entirely by hand, but machine drills have come into extensive use during the last few years. The power used is usually either compressed air or steam, conveyed through flexible tubes from the compressor or generating station to the drill. This consists of a valve motion with a piston attachment, against which the drilling bar is clamped. The piston acts as a hammer, and as it is capable of striking from three to six hundred blows each minute, the drilling bar being automatically turned at the same time, the advantage gained by this method over hand labour can be readily perceived.

Fig. 8.



The Sullivan Rock Drill.

Fig. 9.

Ingersoll Drill Mounted on Tripod.

Fig. 9a.

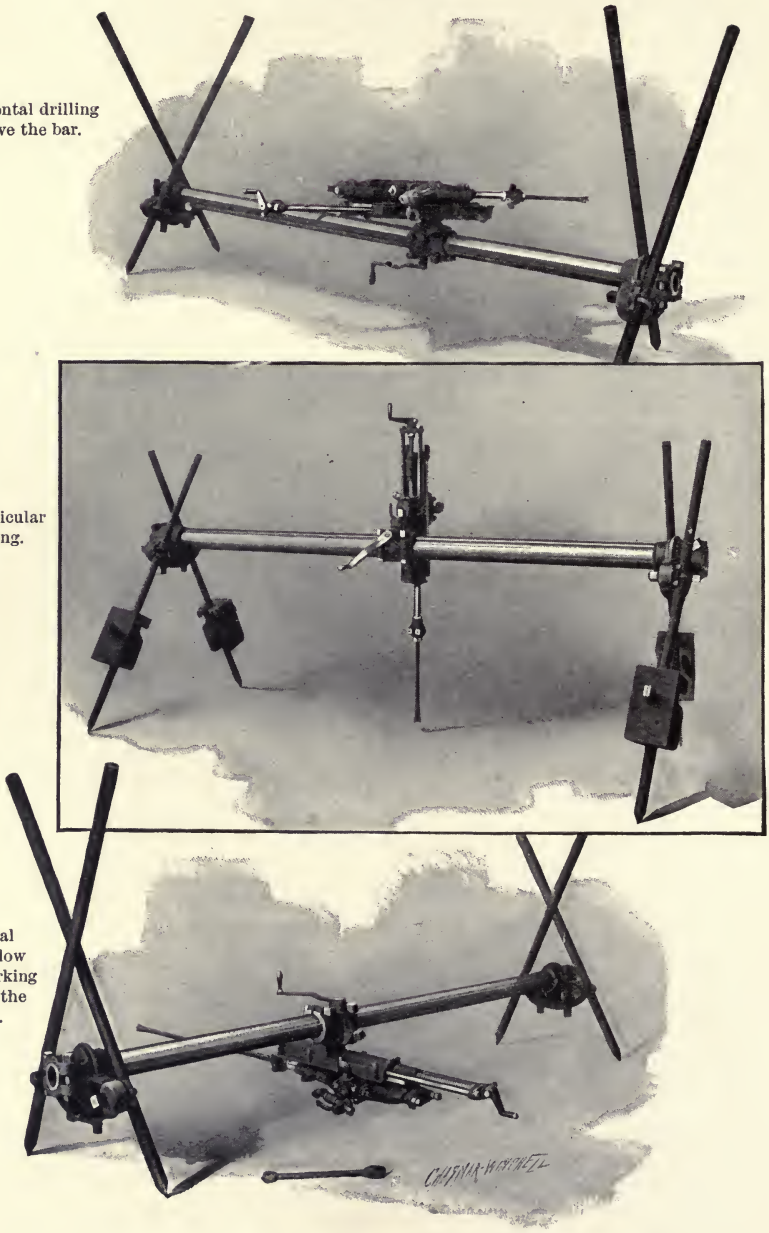
Ingersoll Drill Mounted on Column.

FIG. 10.

Horizontal drilling above the bar.

Perpendicular drilling.

Horizontal drilling below the bar (working close to the ground).



THE SULLIVAN QUARRY BAR, SHOWING ADJUSTABILITY.

The machine is supported on a weighted tripod for use on ledges or in open ground, or mounted on a column or shaft bar for work in crevices or underground galleries (see Figs. 9 and 9A). The tripod is easily adjustable for undercutting as required.

While the majority of rock drills in use are of American manufacture, the progress that has been made in this direction by engineering firms in Great Britain has been considerable, and British-made machines of this class are obtainable that for durability and efficiency will bear comparison with any that are on the market.

The Quarry Bar.—An implement used in connection with machine drills is known as the quarry bar. This consists of a steel bar 6 to 10 ft. in length, supported on four legs, and on which the drill is mounted. For heavy work the under side of the bar is fitted with a rack and pinion adjustment. The use of the quarry bar ensures that the holes drilled shall be in alignment and at the same angle for the entire length of the bar. Drilling machinery of these types has been in extensive use in American marble quarries for many years, but so far as European quarries are concerned, it has only been during the past few years that such methods have been adopted. Machine drills have recently been used in French and Belgian quarries with good results, but their use is not by any means general, although the advantages secured over hand-drilling processes are so apparent. The quarry bar is sometimes used for channelling work, a special bit, or steel, known as a "broacher," being employed to break out the marble between the drill holes.

Attempts have been made of recent years to induce quarry owners to adopt electrical energy for the operation

of drilling machinery. These, so far as European marble quarries are concerned, have met with but a limited amount of success. The method is claimed to possess distinct advantages, the loss of energy encountered in the transmission of power from the generating station

FIG. 11.

THE WIRE SAW IN OPERATION AT TINOS, GREECE.

being stated to be much lower than is the case either with compressed air or steam.

Sawing (The Wire Saw).—This method of extracting marble has been in use for a little over twenty years. The "saw" used is an endless wire rope, made up of three strands of steel twisted together, the length of the

FIG. 12.

ENLARGED PHOTO OF CUT MADE BY WIRE SAW, SKYROS, GREECE.

wire varying in accordance with the work to be done. The wire is passed round a driving wheel, and carried on pulleys from the engine-house right around the quarries, the speed at which it travels being from 12 to 14 miles per hour. A sliding carriage is placed at a convenient point in the circuit, giving the necessary tautness to the wire throughout. The wheel employed for driving purposes is about 4 ft. in diameter, this size having been proved by experience to get a good grip on the wire and obtain the best results. The guiding pulleys are erected on movable standards. These vary in size according to the nature of the work they have to do. Where the wire has to be carried in a direct line, a pulley of 6 in. diameter is of sufficient size; but where changes of direction have to be made, a diameter of not less than 2 ft. is necessary, in order that the wire be not unduly strained.

The wire saw serves two purposes. First, it is employed for cutting the stone from the quarry bed, and, second, in sawing the blocks thus obtained to the required dimensions. Where the formation is suitable, dimension stone can be quarried direct; in other cases, huge blocks are extracted, these being afterwards cut to size (see Figs. 11 and 12).

For cutting large blocks into merchantable dimensions, the wire is guided to the block, and a frame erected to carry the pulleys over which the wire runs in the required direction. In cases where the amount of work to be done justifies the outlay, the saws occupy fixed positions, the marble being conveyed on trucks to the saw. One wire will thus be utilised for the cutting up of several blocks.

A method of employment of the wire saw in use in Belgium and the north of France consists of sinking holes

Fig. 13.

The Penetrating Pulley Operating at Bergniorny, Belgium.

from 2 to 3 ft. in diameter by means of a revolving cylinder, the bottom edge being serrated and, in some instances, being set with bort, or black diamonds. The shaft having been drilled to the depth required, the core is extracted, standards are erected, and the marble cut from the rock as before described (see Fig. 14). The core from the hollow drill is sometimes available for columnar work.

The idea of the wire saw dates from 1854, the credit for the invention belonging to M. Eugène Chevallier, who on April 8th of that year obtained a patent for the invention, the description of which concludes as follows: "In a word, I claim essentially, as basis of my invention, the employment, as sawing instrument, of one or several wires or metal cords or chains acting in a continuous or alternating rotary motion driven by hand or machine, with the property of flexibility and linear reduction, to bite, at the same instant, the block along all the imaginable outlines which may be needed for sculpture, statuary, mosaic, and other artistic and industrial objects."

The system remained unutilised for over twenty-five years, and was revived by M. Paul Gay in 1880. The pulleys with universal joints, enabling the wire to be turned in all directions, were invented by M. Michel Thonar, of Belgium, in 1884, together with a number of improvements in the system, rendering it of practical utility.

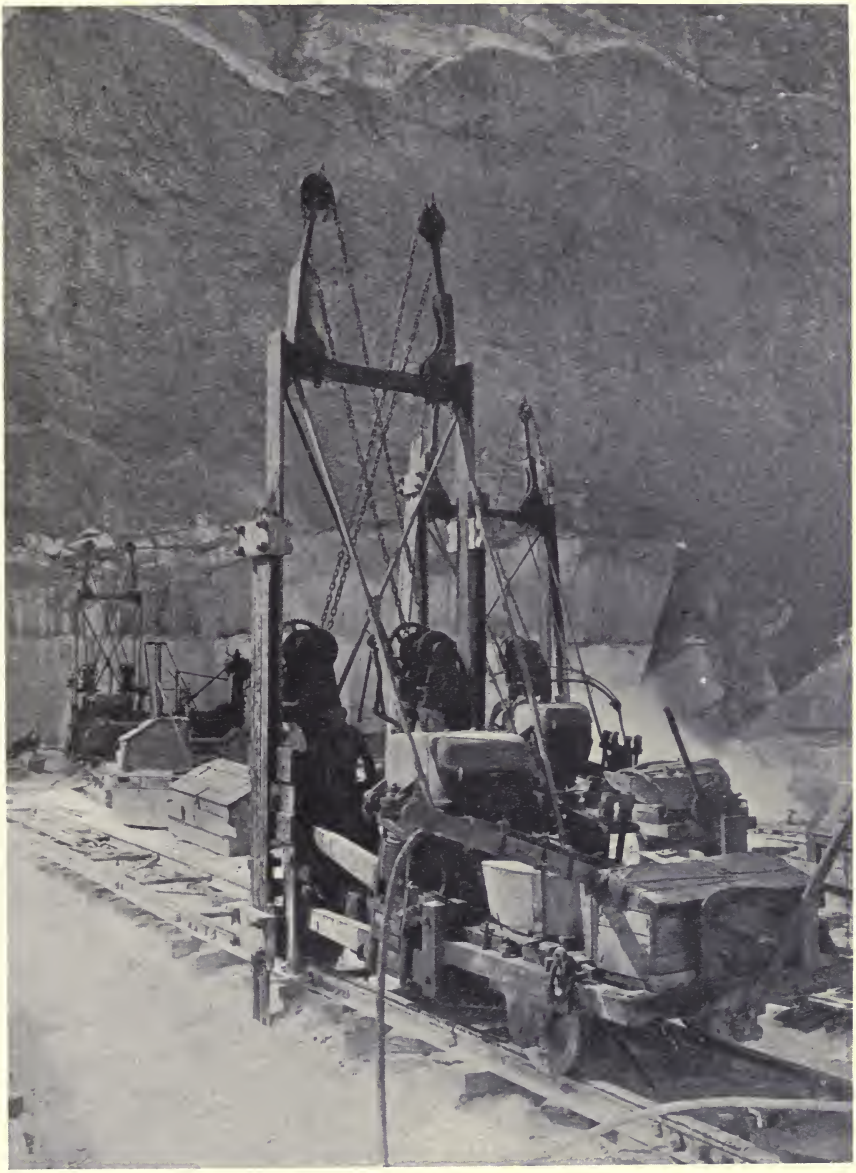
The Penetrating Pulley.—Previous to 1898 the use of the wire saw for quarrying was greatly restricted, as, owing to the difficulty of guiding the wire in a slanting direction, vertical shafts had to be sunk to receive the standards carrying the pulleys; but the introduction of the "penetrating pulley" in that year was the means

FIG. 14.

PERFORATING DRILL FOR SINKING HOLES FOR WIRE SAW.
Lifting out the marble core.

of greatly enlarging the use of the wire saw for the extraction of stone. The pulley consists of three parts:—(1) The pulley: This is a steel disc 50 cm. (19·6 in.) in diameter and 7 to 8 mm. (·27 to ·31 in.) thick, grooved on its edge to receive the wire. On the central part of the disc and projecting on each side is a boss supporting a steel axle 25 mm. (·97 in.) long. (2) The fork: This takes the shape of a hollow steel bar, 64 mm. (2·4 in.) in diameter, grooved at the lower end to receive the pulley, and which can be lengthened by a series of tubes of similar diameter. The bottom of the fork acts as a bearing, on which the pulley runs. (3) The carriage: This consists of a standard which can be placed in position by three screws or guys. The standard carries a screw and drum attachment, by which an automatic progressive motion is given to the fork from the rotation of an exterior pulley, on which the helicoidal wire runs. The operation of extracting stone is as follows:—Two holes are first sunk to receive the fork on which the pulley runs. The holes, 6 to 7 cm. (2·3 to 2·7 in.) in diameter, are easily made by an ordinary jumper in the hands of a skilled workman, or machine drills can be employed to make the necessary sinkings. The standards carrying the wire having been placed in position, and the wire set in motion, the penetrating pulley is brought close to the rock. The thickness of the pulley being slightly less than the diameter of the wire, the latter, projecting from the edge of the pulley, wears into and bites the rock, forming a groove into which the pulley enters (see Fig. 13). Sand and water are fed to the descending wire, and the fork supporting the pulleys following the hole made to receive it, the wire is carried

FIG. 15.



THE WARDWELL CHANNELLER OPERATING BY ELECTRICITY AT PROCTOR, VERMONT, U.S.A.

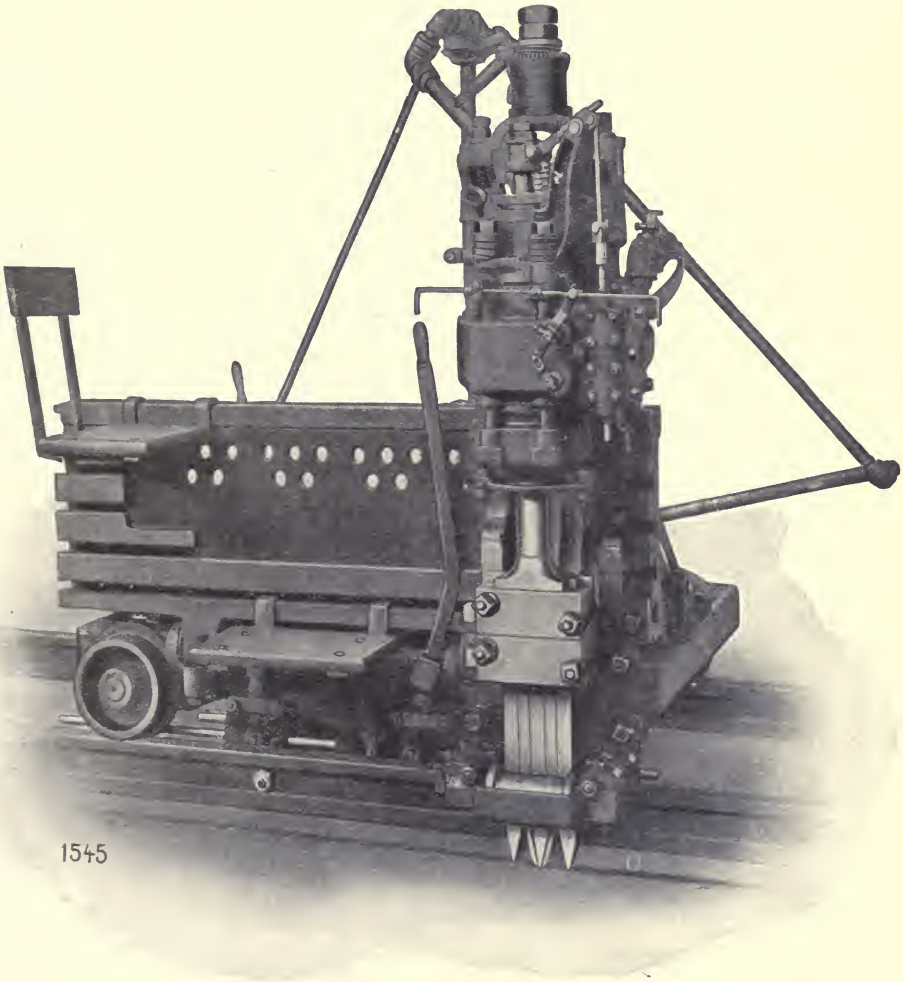
through the ground from one standard to the other, making a cut in the direction required. Cross-cuts are obtained by altering the position of the standards. Cuts can be made along a length of 10 to 15 metres (10·9 to 16·3 yds.), and for an equal depth, the progress of the cut being from 4 to 15 cm. (1·56 to 5 in.) per hour, this depending on the nature of the material and the length of the cut.

The penetrating pulley was first used at the Campanile Quarry, Carrara, in March, 1898, the owner of the quarry, Signor Alfredo Corsi, purchasing the pulley forthwith, with the right of reproduction. The pulley is manufactured, by arrangement with the owner, by MM. Thonar Dejaiffe et Cie., of Namur, Belgium. The method of extracting marble by means of the wire saw is largely used in France, Italy, and Belgium, and almost exclusively used in the Greek quarries owned and controlled by Marmor Limited. The system is not looked upon with favour by American quarry owners, nor, with the exception of a single installation in occasional operation at Connemara, is it in use in this country.

Channelling.—Whilst this method of extraction is but little known on the eastern side of the Atlantic, it is the most extensive in use throughout the United States of America. There are several types of channellers on the market, the manufacturers of each type claiming to produce the best machine in existence. For a detailed description of particular machines, the reader is referred to the catalogues issued by their respective manufacturers. It may be generally stated, however, that the productions of the Sullivan Machinery Company, of Chicago, are in most extended use on the principal marble

fields of the United States; and, while other types of channellers have attained considerable success in the

FIG. 16.



THE INGERSOLL TRACK CHANNELLER.

various mediums in which they have worked, the supremacy of the Sullivan machines in the marble industry of America has been amply demonstrated. The

productions of the Ingersoll-Sergeant Drill Company, of New York, are also in considerable use, both in America and, to a lesser extent, in Belgium, and the Wardwell Channellers, manufactured by the Steam Stone-cutter Company, of Rutland, Vermont, are well known on both sides of the Atlantic (see Figs. 15, 16, 17).

Before commencing quarrying, a level floor is cleared, on which the channelling machine can operate. The machine usually consists of a vertical boiler mounted on a heavy carriage, which runs on a railed track. The types of machinery vary somewhat, but the working principle in all of them is that of a cylinder, with valve and piston attachment, actuating, either directly or by means of levers, a gang of cutters fixed on the side of the machine, and giving them a sharp, percussive motion. The cutters strike the rock at a rapid rate, and the machine being at the same time propelled in a forward direction, a channel is sunk in the floor or ledge of the quarry on which the machine is travelling to the depth desired. Some of the machines are built to allow of a gang of cutters to operate on both sides at once, making parallel channels, one each side of the track, others with a duplex action, working two sets of steels in alternation in the same channel. Later types of channellers are electrically driven.

The work accomplished by the channelling machine varies in accordance with the nature of the marble. A fair average in a sound white marble would be for single-gang machines, 100 to 120 channel ft. (*i.e.*, the equivalent of channel 20 ft. long and 5 to 6 ft. in depth, surfacing two walls) per day of ten hours. The advantages claimed for this method of extraction are a lessening of the cost of extracting stone and a considerable reduction in the

Fig. 17.

The Sullivan Channeller in Operation at Rutland, Vermont, U.S.A.

amount of waste material, the face of the blocks secured by channelling being almost as true as a sawn face.

The working heads of later types of machines are arranged so that they may be slung back, inclining the steels at an acute angle, thus allowing of working back into the rock, and so enlarging the quarry floor (see Fig. 22). As the quality of the marble in many of the formations improves with the depth of the quarry, the method of undercutting adopted eliminates the necessity of removing a considerable amount of top bed, and enables the better qualities of marble to be obtained at a minimum of cost. Where the dip of the quarry is at an angle, the rails on which the machine runs can be fitted with a rack and pinion device, so that the extraction of blocks may, if necessary, follow the line of the marble formation.

After a series of channels have been cut in a quarry floor, cross channels are made, the quarry bar, with machine drills, being sometimes employed for this purpose, while the channeller is working elsewhere. A single block is then broken out, and a machine known as the *gadder* comes into operation. This consists of an upright standard, mounted on a low carriage and adjustable to any angle. A machine drill is attached to the standard, on which it slides up and down, and the drill having a swivel attachment, can be made to operate in any direction. Blocks are thus obtained to any required sizes, and the gadder operating right down to the base of the channelled layer, and, where necessary, along its lower edge, the bed from whence the blocks are extracted becomes, in its turn, the quarry floor (see Figs. 19 and 19A). An undercutting channeller is sometimes used to separate the blocks from their bed.

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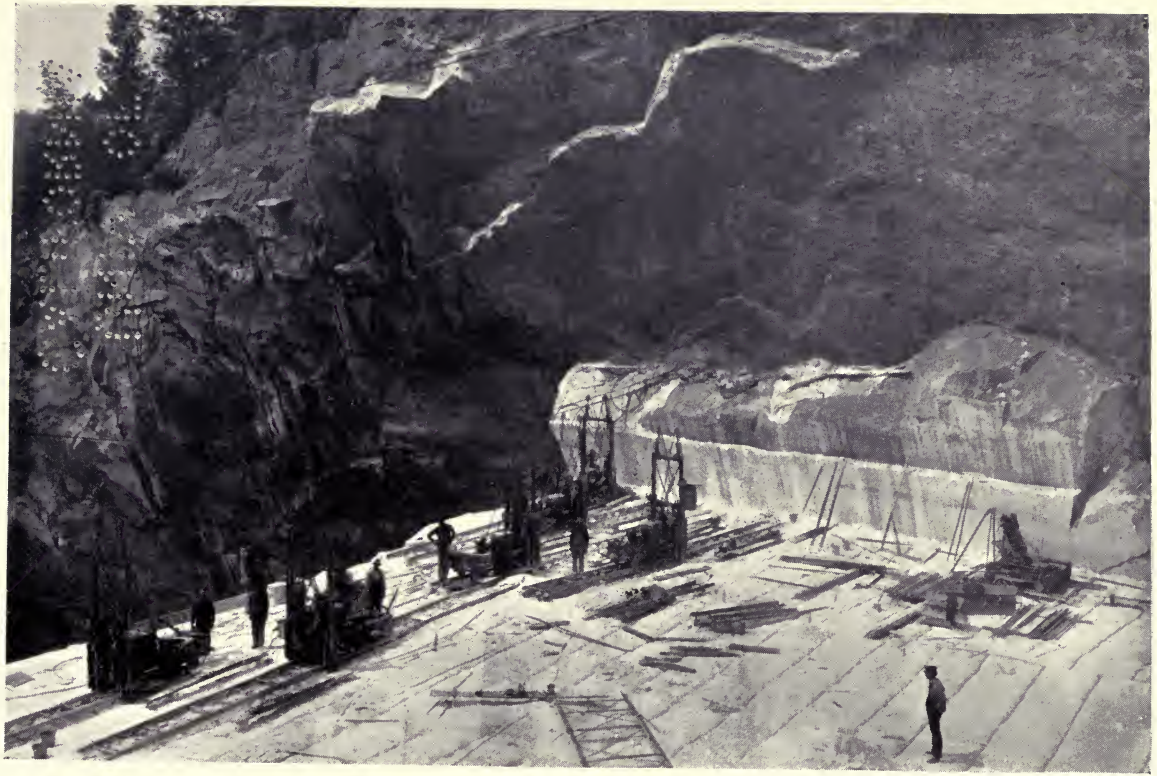
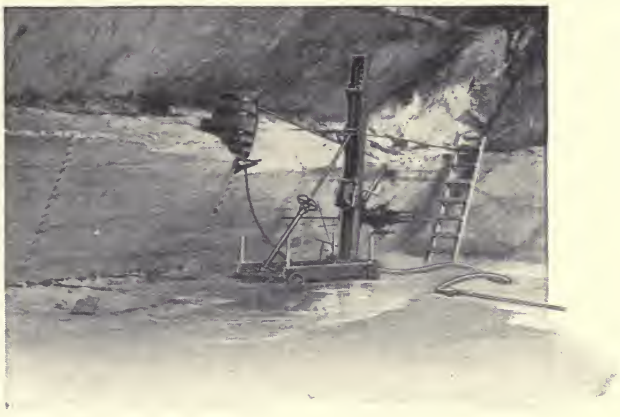
FIG. 18.



A VERMONT (U.S.A.) MARBLE QUARRY.
Note the channels in the quarry floor.

[To face p. 45.

Fig. 19.

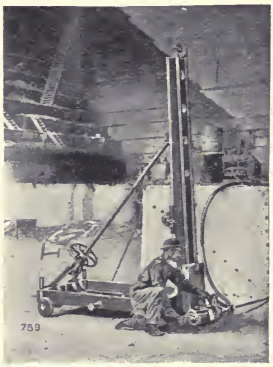


The Gadder at Work on Undercut Slope.

The principal manufacturers of channelling and gadding machinery in America are the Sullivan Machinery Company, of Chicago; the Steam Stone-cutter Company, of Rutland, Vermont, whose Wardwell Channeller has been used to a considerable extent in Great Britain on hard york, free-stone, and millstone grit; and the Ingersoll-Sergeant Drill Company, of New York. Channelling machines of light build are also made by the Bramley Engineering Company, Ltd., of Bramley, near Leeds, and by George Anderson & Co., Ltd., of Carnoustie, Scotland.

Another interesting development that has taken place in the United States of late years is the mining, rather than quarrying, of marble. This is specially prevalent in the Vermont district, where a considerable amount of the marble lies vertically to the surface, and at a depth of from 200 to 300 ft.

Fig. 19a.



The Gadder Cutting Angle Pieces.

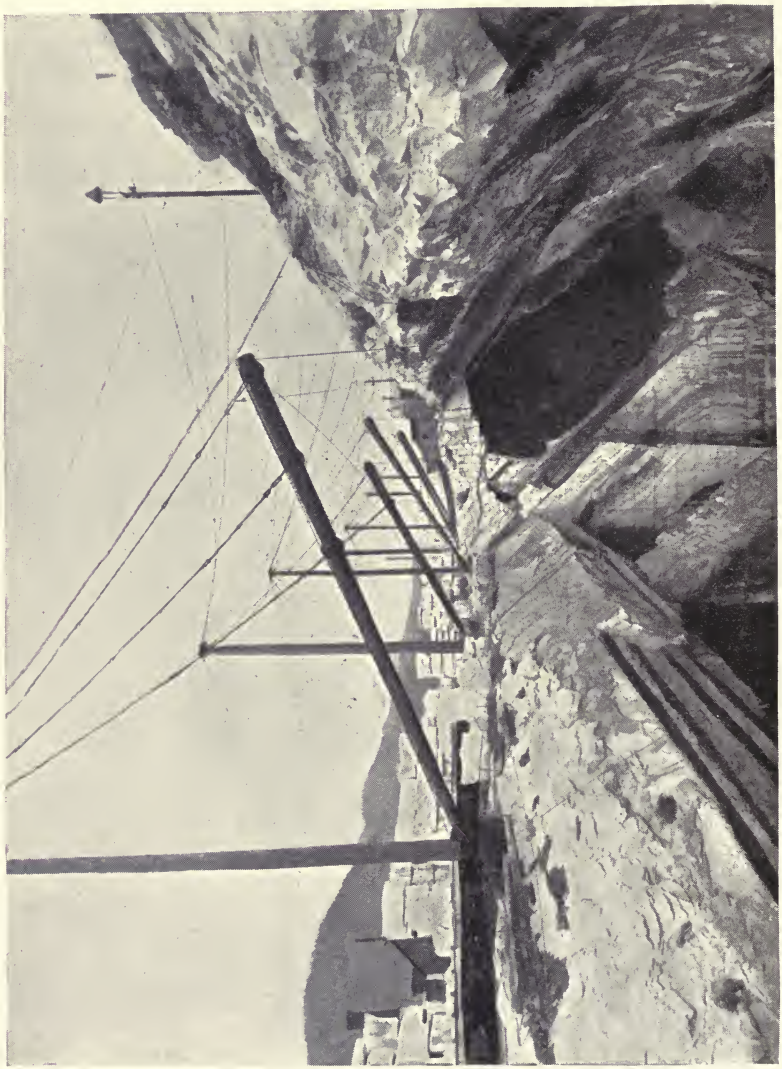


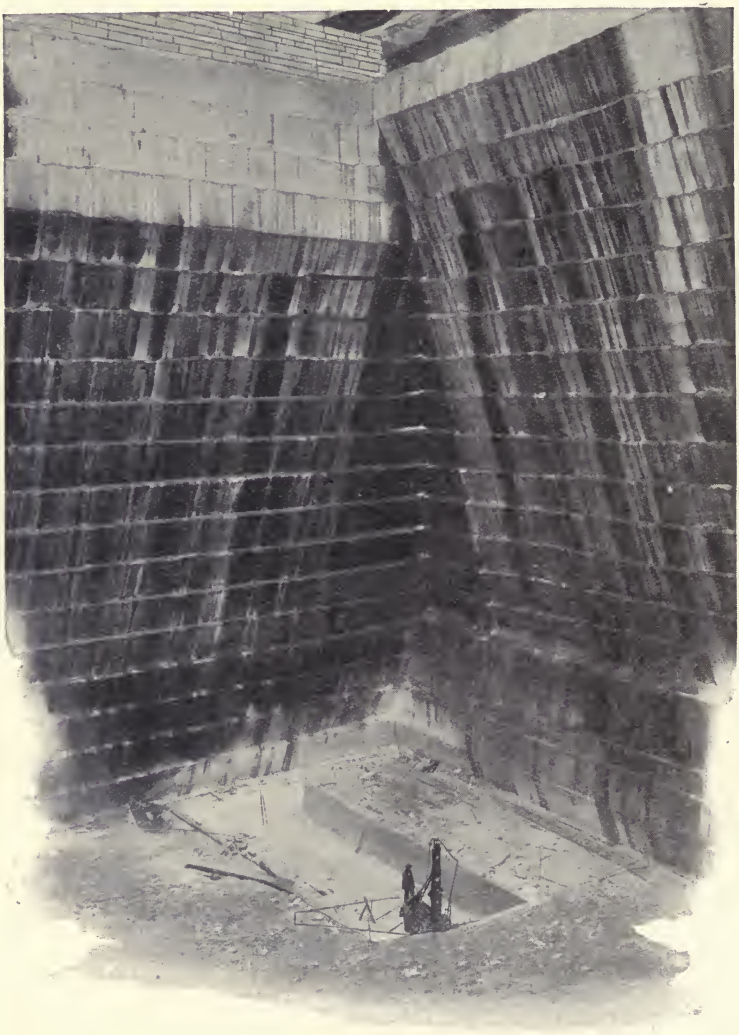
FIG. 20.

MINING FOR MARBLE: A VIEW IN THE VERMONT DISTRICT, U.S.A.

turns to a horizontal position. The method adopted is to make a horizontal cut about 6 ft. below the turn of the formation, and blast down to it, thus making a space in which the channelling, etc., machines can work. The tunnels are, in some instances, carried close on 1,000 ft. from the face of the quarry. Walls of solid marble are left to carry the roof, the extractions taking the form of galleries extending the entire depth of the formation.

The system in force in American quarries results in the securing the maximum amount of marble with the minimum of waste, and permits of a small opening being made on the surface, the quarry floor being enlarged by the undercutting of the walls where the formation allows, thus reducing the amount of overburden that often has to be removed in order to extend quarrying operations; and while there seems no reason why the system should not be adopted advantageously in certain of the European marble formations, its application to the less accessible parts of the Carrara district, for instance—where a necessary part of the quarryman's training is to acquire a coolness of nerve and agility equal to that of a trained mountaineer—would hardly be practicable. The fact that marble is used to a large extent for building purposes in the United States, too, has some bearing on the matter. The channelling system is more costly in adoption than is that of sawing by the wire, and is only economical where there is a large and continuous output. A single channelling machine will do twice as much work in a given time as will a wire saw, but requires more skill to be displayed in its operation than does the latter; the power consumption, too, is higher, and so are the wages of its operator.

Fig. 21.



Interior of a Tate, Georgia (U.S.A.), Marble Quarry.

Note the method of undercutting the walls. The depth of the quarry is over 175 ft.

The demand for any particular coloured marble is of comparatively small extent, and with the possible exception of Belgian "Granit" and Rouge, there is hardly a coloured marble quarry in Europe that could profitably employ an entire American equipment. There remain the white marbles. The present appliances are sufficient to satisfy

FIG. 22.

UNDERCUTTING WITH THE SULLIVAN CHANNELLER.

existing requirements, and are suited to the work they have to do. Failing a new and extensive demand, it is unlikely that new methods of quarrying will, so far as Italy and Greece are concerned, be sought after.

It is worthy of note that whilst the wire saw is in general use throughout Europe, it is not looked on with

favour in America; and although its adoption has been attempted on several occasions, the various concerns experimenting have reverted to channelling as being the more economical method of securing material. A trial of the respective merits of the competing systems would be followed with great interest by all connected with the industry.

CHAPTER IV.

Marble as Building Material.

THE developments that have taken place of recent years in the use of marble for constructional purposes call for more than a passing mention. Previous to 1898 the only erections of this nature were the Marble Arch, built of Italian marble, and the Junior Constitutional Club, Piccadilly, faced almost entirely with a pink Norwegian marble. The Sun Fire and Life office, facing the south side of Trafalgar Square, and erected in 1865, included a doorway and pediment of Sicilian, the window jambs and heads, as well as the quoins and cornice, being of the same material; but apart from these instances, marble, as building material, was conspicuous only by its absence.

The exploitation on commercial lines of the ancient Greek marbles mentioned in Chapter II.* has had its effect on London architecture. First introduced in 1898 for portions of the New York Mutual Assurance Company's building on Cornhill, E.C., Pentelikon marble took time to win its way to the favour of British architects, who, with the conservatism that has been largely responsible for the stability of our national work, were disposed to look askance at what was to them an untried material. Some eight years elapsed before the profession could be persuaded as to the suitability of this marble for building purposes, and its ability to withstand the ravages of the London atmosphere, but eventually one of the leading members of

* See pp. 20, 21.

FIG. 23.

A PENTELIKON DOORWAY.

The first instance in London of the use of Greek Pentelikon.

the profession was induced to give the material a thorough trial. The first building to be erected in London of white marble was the new premises of Messrs. Mappin & Webb, situated in Oxford Street, from the designs and under the supervision of Mr. John Belcher. This was shortly afterwards followed by Messrs. D. H. Evans's premises in the same street (see Fig. 24), which, when completed, will be the more extensive erection of the two. The buildings on the corner sites at the junction of St. James's Street and Piccadilly are also erected in this material, and, for the first time in the annals of British architecture, Greek marble is well on its trial.

Judging from the first instance quoted, the material, after ten years of exposure, weathers well, the detail work being as sharp as when fresh from the tool, and all the characteristic marble features being retained. With the later work, slight stains have appeared in the polished pilasters fronting Messrs. Evans's premises. The quarry owners are confident that these will disappear with the passing of time; but opinions are divided on this point, and the matter of their permanence or otherwise must be left for the future to solve. It is noticeable that the occurrence of the stains is more prominent in the parts having a polished face than in the remainder of the work as yet carried out, which is finished with a dull surface. It is within the writer's personal knowledge that no acid was used in the polishing of this portion of the work, and as the material is non-absorbent, it is evident that the blemish, if such it be, is inherent in the marble. Apart from this peculiarity, which time may remedy, Greek marble appears suitable in every respect for use for exterior work in this country. It is more compact than

the Italian varieties, and, when semi-polished, presents a surface that is practically impervious to atmospheric impurities. It has been extensively used for exterior work in Germany, has been introduced with success in leading Continental centres, and is gaining a footing in the United States of America. An advantage from the architect's standpoint is that, owing to practical difficulties in working the material at the quarries, the use of Greek marble for masonry work makes it advisable for the material to be worked in this country; effective supervision, both of material and workmanship, is thus maintained, and a standard of efficiency secured that would hardly be possible were the work to be executed abroad, as would probably be attempted were Italian marble to be used. The nation is also benefited, inasmuch as the wages paid in its working go into the pockets of the British workman, and are spent in the country.

Attempts to introduce Italian marble for building purposes have not been altogether attended with success. The softer varieties are quite unsuitable for this purpose, as may be seen on viewing the pilasters on the front of the Tivoli, Strand, W.C. It is sometimes possible, after a shower of rain, to see that these really are marble, but ordinarily this would not be discernible to other than an exceedingly cute observer. So far as the harder varieties are concerned, it is noticeable that since the instance quoted of over forty years ago, Italian white marble has not been used for the exterior of any important building, while the use of the Pentelic variety is increasing to a considerable extent. This is possibly due to the fact that the organisation controlling the latter material is a single one, whereas firms dealing in Italian marbles are many

Fig. 24.

Building in Marble.

Messrs. D. H. Evans & Co.'s Premises, Oxford Street, W.

[*To face p.* 54.

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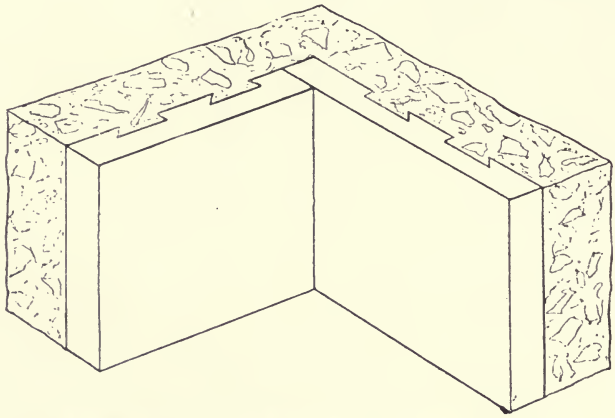
and of divided interests. It certainly is not the case that Carrara marble is unsuitable for outside use for London buildings. The ordinary quality of Sicilian marble is close in texture and practically non-absorbent. Where properly selected, it weathers well, and as the cost of working is lower than that of Greek marble, it should possess a distinct advantage over the latter material. The writer recently had an opportunity of examining the exterior of the building facing Trafalgar Square, already referred to. With the exception of the moulded bases of the chimney-stacks, which are honey-combed from the drippings of rain-water from the projecting moulded course at the top of the stack, no trace of effervescence or disintegration was apparent. The copings and window jambs and sills, although of a distinctly yellow tinge, were to all appearance impervious to atmospheric influence, while the details of the carving and the arrises on the moulded portion of the work are as sharp and as clearly defined as freshly moulded terracotta. The building is in a central position, and, up to a few years ago, was, being of greater elevation than the adjoining erections, fully exposed to atmospherical influences from all sides.

It will be possible in future years to make a comparison of the weathering qualities of selected Italian and Greek marbles under exposure to the vagaries of the London atmosphere. The masonry of the Queen Victoria Memorial, facing Buckingham Palace (an instance of imported worked marble), is constructed of the Italian variety, while the buildings occupying the corner sites of St. James's Street and Piccadilly are faced with Greek Pentelikon. An hour spent in practical observation is of greater value than days spent in studying text-books, and readers desirous of a

Fig. 25.

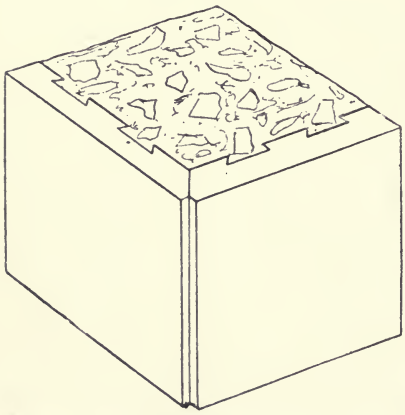


Marmocrete: Treatment for Internal Angles.

full comparison of the respective marbles cannot do better than examine the one, take a short walk across St. James's Park, and, after viewing the other, form their own conclusions.

One of the later adaptations of marble for building purposes is a process patented by Mr. Arthur Lee, and registered under the title of "Marmocrete." The process consists of the application of slabs of Pentelic or other suitable marble of convenient thickness, having undercut grooves or channels in the backs of the slabs, as marble facings to steel erections, the back being filled in with concrete in the usual manner. Blocks

Fig. 25a.



Marmocrete: Treatment for External Angles.

of Marmocrete can also be manufactured for building purposes, the casing being of marble 1½ in. in thickness, grooved on the back as described, and worked with a check angle on returned faces, the filling being of Portland cement and sand, with marble chippings. It is claimed that the use of this process will make it possible for a marble building to be erected at about the cost of Portland stone. The process is available as a facing for reinforced concrete work (see Figs. 25 and 25A).

Coloured marble has only been used to a small extent for building purposes in this country. Perhaps the best instance of such use is the Junior Constitutional Club, Piccadilly, W., the greater part of which is faced with Norwegian marble. The material has weathered well, but the experiment made in its use has not been repeated, possibly on account of its cost, the marble being a most difficult one to work.

Thanet House, Fleet Street, E.C., is another instance that may be cited. Here the entire facing, from the second floor upwards, is carried out in Mazzano (Brescia) marble. In this instance the surface is slightly pitted where exposure to the weather is most prevalent, but appears sound in other respects, and where shielded from wind and rain, preserves its polish intact. Where the effect of atmospherical influences is most pronounced, the surface is quite eaten away, and a crust has formed, which may be resistant to similar influences in the future, on the face. This is specially apparent in the domes at the top of the building, the surface of which resembles exposed Portland stone. The weathering action, both here and in other portions of the building, leaves the surface a clear white, giving a rather pleasing effect.

Instances of the use of coloured marble in London exteriors are : Swiss Cippolino—Columns, Electra House, Finsbury Pavement, E.C. ; Verde Antico, banded with Portland Stone—Gaiety Theatre, Strand, W.C. ; Brêche Violette—Columns, Hamilton House, Victoria Embankment, E.C., and Columns and Rusticated Pilasters (the latter boxed up out of $1\frac{1}{2}$ in. material) at 22, Oxford Street, W. ; Campan Vert—Pilasters, Gainsborough House, Hanover Square, W. ; Rouge Jaspe—Panels at side of entrance, Royal Society of Painters in Water Colours premises, Pall Mall East, S.W. ; Cornish Serpentine—Tooth's Galleries, Haymarket, S.W., and Bank of British North America, Gracechurch Street, E.C. (The comparison between the weathering qualities of the red and green varieties of serpentine in the Haymarket illustration is interesting.) Tinos—Messrs. Debenham's premises, Wigmore Street, W., and Messrs. Abbott's premises, 6-7 Poultry, E.C. ; Belgian Rouge—Tooth's Galleries, Haymarket, S.W., and *Sheffield Telegraph* building, Fleet Street, E.C. ; and Swedish Green at the new Egyptian Hall, Piccadilly, W. ; Greek Cippolino—Columns at the entrance of Messrs. Waring's premises, Oxford Street, W., and Columns and Pilasters above ground-floor level at Messrs. Evans's premises, etc. Ashburton (Devonshire) marble is employed in the entrance to the Restaurant at Victoria (S.E. & C.) Railway Station, S.W.

With the exception of Greek Cippolino, and possibly Ashburton, Tinos, and Swedish Green, the instances that have occurred have resulted in demonstrating what to avoid rather than what to use. Generally speaking, it appears that while certain varieties of marble are available for exterior work, their general use is inadvisable, for the

CIPPOLINO (EUBŒA, GREECE).

[*To face p.* 58.

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reason that discoloration and disintegration will ensue as a result of atmospherical impurities—generally sulphuric acid, generated by the action of rain-water falling through a smoke-laden atmosphere on to soot-covered buildings—the effect sought to be produced by their use being thus speedily lost, even if nothing worse happens. The red marbles mostly contain clayey veins and patches, which disintegrate under the action of sun, rain, and frost. With the greens, efflorescence results; the violets lose their colour; while with breccias the colours fade, and a leaching-out becomes apparent along the lines of the cementing medium of the material. Laminated marbles waste in their softer layers, leaving the harder parts exposed, and these in the course of time will break away. In the exceptions named, these tendencies appear to be successfully resisted. Sufficient time has not yet elapsed, however, for the effect of the London atmosphere on the surface of the marbles to be ascertained with certitude.*

One point should be noted. If for any reason it is considered advisable to employ coloured marble for exterior work, the material should always be solid, or at least 4 in. thick. To use it boxed up in thin slabs is a waste of good material, and should be avoided in all cases. The ordinary methods of fixing thin slabs are altogether inadequate for exterior work, and they are bound, sooner or later, to work loose. The selection of the material is also a matter that requires more than ordinary attention.

* See also Hopton-Wood, p. 109.

CHAPTER V.

Uses of Marble (other than for Building Purposes).

THE uses of marble, apart from building purposes, may be grouped under six heads—Sculpture, Monumental, Shop-fitting, Electrical, Furnishing, and Decorative. The supplies for sculpture or statuary purposes are chiefly drawn from the Seravezza district, the quarries of Mont Altissimo producing the best quality. It is also obtained in considerable quantity from the Carrara district generally, but the durability and reliability under the tool of other than Seravezza statuary is considered to be lower by British sculptors. A variety quarried at St. Béat, in the Haute Gironde, is held in great favour among French sculptors, some of whom are stated to prefer it to any Italian variety. Specially selected Greek Pentelikon is also coming into favour. The texture is close, and the sparkling appearance of the crystals give a *live* effect unapproachable in any other medium. Care must be taken, however, to avoid the greyish-white micaceous seams that are sometimes encountered in this formation. While the Greek variety is harder than is the Italian, its wearing qualities are higher, and in weathering it is asserted that it assumes a warm, creamy tint which is most effective. The Parian marble of antiquity is as yet only obtainable in small sizes and at rare intervals. Finest Seravezza statuary is most difficult to obtain free from blemish, and is easier secured in small blocks; consequently, the price of first-quality material varies to a

large extent, according to the size of the block required. Small blocks of good quality, of sufficient size for a bust or mask, are at times obtainable for as little as ten or twelve shillings per foot cube, while a block of sufficient size for a colossal figure (say four times life size) would hardly be obtainable at four times the price.

While the art of sculpture does not come within the purview of these articles, some hints respecting the selection of the material to be used may be of service.

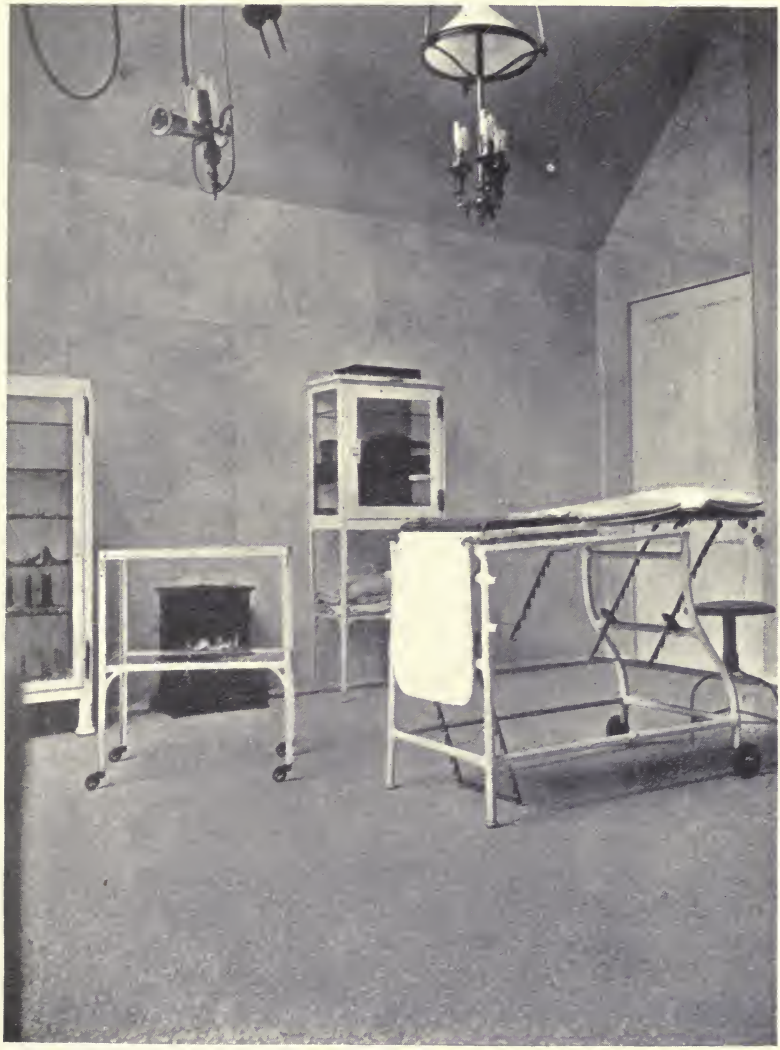
Marble for statuary purposes should never be selected in bright weather. Veinings and discolorations are more difficult of discovery at this time than at any other. A dull day with a good light is the best time for inspection; if after a shower of rain, so much the better. Provided no rain has fallen, the blocks should be soused with water; veins and stains can then be more readily perceived. If possible, have each block slung and struck with a hammer. If the sound of the blow is dull and heavy, look out for cracks. Should a hard, metallic tone be emitted, the marble will be heavy in working; but if a soft, clear ring is heard, the material is sound, and will both work and wear well.

Monumental.—The supplies of marble for monumental purposes are drawn from the whole of the Carrara district, the greater proportion of this class of work being imported in a worked or partially worked state. This is accounted for by the fact that wages, both for mason work and carving, are much lower in Italy than at home, and that the waste from crosses, etc., can be worked up into small ornaments to greater advantage by Italian workmen than could be the case in this country. While the application of pneumatic tools to marble working has

made the fashioning of "purpose-made" tombstones possible to a small extent, practically no marble work of the cheaper description is executed in this country. This class of work is generally imported in a worked state, only the fitting, lettering, and fixing finding employment for British marble masons.

Shop-fitting, Purposes of Utility, etc.—The use of marble for the fitting up of retail shops is on the increase. The principal demand comes from businesses where a cold, hard substance impervious to moisture is required. The demand for marble for shop-fittings is principally from butchers, dairymen, poulterers, and retailers of fish and provisions. Sicilian marble is principally used, and the work is mainly executed at home. The utility of the material for these purposes is unquestioned. Another demand that has come into force of recent years is that of marble for lavatory fittings and sanitary work generally. The Belgian Rouges and Saint Anne's marbles are principally used for these purposes. The material is generally worked in Belgium, and supplied ready for fixing. Sicilian marble has been used to some extent for partitions for sanitary work, but has been found to stain readily. The kitchens of restaurants are sometimes lined with marble, and instances have occurred of its use for stable fittings. The employment of marble for lining the walls of operating-rooms, etc., in hospitals is on the increase. A selected variety of Sicilian is used, all external angles being rounded and internal angles hollowed out of the solid or "coved." The junction with the floor is effected by a coved skirting, thus providing a surface that is readily cleaned and affords no lodgment for disease germs.

FIG. 26.



"CLEANLINESS AND LIGHT."

An Operating-room lined with Sicilian Marble.

Electrical.—The demand for a material possessing high non-conductivity and rigidity for use for switch-board purposes has, since the progress that has occurred in electrical science, been considerable; and while several mediums have been tried and found wanting, white and dove-coloured marbles have stood most of the tests that have been set. Marble for this purpose requires careful selection. It should not be too hard, or the risk of breakage during the drilling process will be increased; it must not contain prominent veins, or its conductivity will be apparent on the lines of the veining, and leakage of current will occur, electrolysis of metallic substances near the terminals being liable to be set up. At the same time it must not be expensive, and must present a good appearance when worked. The selection of marble best suited for the work is largely a matter of experience; and as defects in material are only discovered after a considerable amount of time and labour has been spent on its preparation, it is advisable for each slab to be carefully examined before being put in hand. A variety of Sicilian marble containing a light blue tinge, the veinings being diffused, will best answer the requirements. Italian dove marble, while not presenting such a neat appearance, is also suitable. The working calls for extreme accuracy, which is best secured where machine rather than hand labour is in more general employment.

Furnishing.—The manufacture of marble clock cases gives employment to a large number of hands both in France and Belgium. The work is specialised, the workmanship and finish of these articles being particularly good. Clock cases are produced abroad at such exceptionally low prices as to make competition impossible in this country.

The supply of polished marble for washstand tops and table-tops for restaurants is attaining considerable dimensions. Italian (Sicilian) and Belgian (Rouge and Belgian Granit) houses can supply stock sizes at low prices, but for purpose-made work the British manufacturer can often supply to advantage. A variety of Spanish Rouge is also used for low-priced furniture.

The use of marble for chimney-pieces is well known. The "Builders' Guide" for 1736 states: "The principal use of marble in architecture is for chimney-pieces, chimney foot-paces, window-stools, pavements, etc.," and gives the additional information that "chimney-pieces of Egyptian or black-sleak'd marble, or rance, or liver-color'd marble, are worth, of an ordinary size, £12 or £14 a piece." These prices would hardly prevail at the present day. The coloured marble chimney-pieces in ordinary use are principally of French, Belgian, or Italian manufacture, but a considerable business is done in the supply of these in British marbles, also in the working of marble slips as insets in wood and other chimney-pieces.

Decorative Interiors.—The use of coloured marbles for decorative interiors had its origin, so far as can be ascertained, with the ancient Romans. No traces of such use are to be found in Grecian architecture, nor are any remains of coloured interiors existing. Mr. W. Brindley puts its introduction as occurring after the conquest of Egypt.* An earlier use is, however, claimed by Mr. Gerald B. Brown. In his treatise on "The Origin of Roman Imperial Architecture," he states: "There are the strongest reasons for locating in the Hellenistic cities, and probably

* Transactions of R.I.B.A., New Series, Vol. III., p. 47.

at Alexandria, one of the most characteristic forms of decoration employed in Imperial Rome—that of veneering brick or concrete structures with marble slabs. The use of costly marbles was coming into fashion at Rome, as Pliny states, in the last ages of the Republic, and there is a curious piece of evidence that the custom was imported from abroad. If, with the assistance of Dr. Mau ("Geschichte der decorativen Wandmalerei in Pompeji," Berlin, 1882, and "Pompejanische Beiträge," Berlin, 1879), the history of Pompeian wall decoration be studied, it will be found that the oldest form of it was the imitation in coloured stones of slabs of variegated marbles (Mau, Geschichte, p. 108). The employment of real marbles was at the time evidently a foreign luxury, very attractive, but too costly for general use. It was reserved for the Romans of the age of display to introduce the technique itself, which was one exactly suited to the genius alike of the Hellenistic and of the Roman Imperial period."*

Cippolino, Pavonazzo, and other rare Roman marbles have been found not only in Rome, but also at Carthage and other ruined cities in West and North Africa; and while it is evident that coloured marble was known and used at a much earlier period (the sarcophagus of Nectanebes I., *circa* B.C. 378, and now in the British Museum, was executed in Breccia Verde or Verde Universelle†), there is practically no proof that such use was extensive in pre-Roman days.

After the downfall of the Roman Empire, and the capture of Constantinople by the Turks, the use of marble

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* Transactions of R.I.B.A., New Series, Vol. V., p. 156.

† W. Brindley: Transactions of R.I.B.A., New Series, Vol. IV., p. 24.

lapsed for a considerable period, to be revived again with the rise of civilisation following the Dark Ages. Numerous instances of the employment of marble are to be found in the ecclesiastical architecture of Europe from

FIG. 27.

Campan Vert and Swiss Cippolino.

Derbyshire Alabaster.

Frosterley.

THE MARBLE PULPIT, BOMBAY CATHEDRAL.
An example of British workmanship.

the tenth century onward ; and while a review of leading instances would be of interest to many, the scope of the present work will not admit of their description. Spain, Italy, France, and the Low Countries abound with such

work; and with each succeeding architectural period the use of marble for purposes of decoration became more prevalent, being at its highest shortly before the French Revolution. It then suffered another relapse, and is again reviving and possibly coming into more general use than at any previous period. So far as Great Britain is concerned, the greater number of the schemes carried through have been worked by foreign craftsmen, the work being imported all ready for fixing. While the proportionate amount of marble work executed in this country has been small, the instances that can be adduced are of the highest class, and there is little doubt that, in this branch of industry, as in many others, British working will ultimately be able to hold its own. This is specially the case with ecclesiastical work, which has largely increased of recent years, and a large proportion of which has been executed by British firms throughout.

The use of coloured marble for decorative purposes is increasing at a rapid rate. The evenness of surface that can be obtained, the effects of light and shade that can be secured, the harmonious colour schemes that can be evolved, all point to marble as being *par excellence* the best medium for the decorative treatment of interiors. Municipal buildings, hotels, banks, offices, restaurants, etc., are nowadays considered incomplete without some such feature, and a large amount of white and coloured marble is also used in the interior decoration of private mansions. While imitations galore are continuously being introduced, the natural product will, where true art is required, always hold its own, no imitation being capable of comparison with the output from Nature's workshop.

CHAPTER VI.

Sources of Production: Italian Marbles.

The supply of material for use in the United Kingdom is drawn from all parts of the world. Only a small proportion is secured from British quarries, partly for reasons that will be referred to later, and partly on account of the fact that several varieties are in regular demand that are unobtainable from British sources. Nearly every country in Europe, the French Colonies in North Africa, and several localities in North and South America are contributaries to British requirements. Whilst our principal supplies are obtained from Italy, France, and Belgium, the Scandinavian and Iberian peninsulas send us considerable quantities; material is also secured from Austria, Germany, and Switzerland. Onyx marble is obtained from the United States, Mexico, Brazil, and Algeria, while from the latter colony, with the adjacent one of Tunisia, come the Numidian marbles of olden times.

The premier position held by Italy for the supply of marble is due to the immense deposits of white marble situate in the Apuan Alps. The formation consists of a mass of crystalline limestone of Triassic Age, covering some 80 square miles, the deposits being estimated at not less than 1,400 ft. in depth. By far the greater part of the deposit is not, however, of commercial utility, partly on account of the material being unsuitable for the purposes for which marble is used, and partly on account of the inaccessibility of many of the usable

varieties, the cost of transport of which would absorb the greater part, if not the whole, of the price obtainable at the seaboard. The supply of white marble is principally obtained from the neighbourhood of Carrara, Massa, and Seravezza. While the marble deposits existing are of great extent, the concessions are so numerous that quarries are crowded together in such a manner as to be a hindrance to economic development. The wasteful methods of

FIG. 28.

MARBLE DÉBRIS AT CARRARA.

extraction adopted in the past have buried thousands upon thousands of tons of good marble under accumulations of rubbish, and the price at which the marble is put upon the market does not allow, in many cases, of the removal of this waste. As a consequence, it is found that while the improved methods of extraction secured by the use of the wire saw have greatly assisted development, the effects of the primitive system, or lack of system, in force until a few years ago are increasingly perceptible. The result is apparent in the greater distances from the seaboard at

which new quarries have to be opened, and the additional cost of transport, together with the increases in wages that are taking place, will probably have an effect in higher prices of the material in time to come. Despite these disadvantages, the available supply is practically inexhaustible, and the neighbourhood can be depended on for the production of ordinary quality marble for an unlimited period. The physical formation throughout the Carrara

Fig. 29.

Transporting Blocks from Quarry to Workshop, Carrara.

district facilitates the transportation of blocks from the quarries to the workshops, and thence to the coast, to no small extent. All the quarries are situated well up the mountain side, and the cost of bringing blocks from their place of origin is, owing to the slope of the land, much lower than on the majority of marble fields. The methods adopted for transporting material from the quarries to the sawing-sheds and *studii* range from the lowering of blocks on skids, and hauling by bullock waggons, to ordinary railway traction. In some in-

stances, material of good quality is obtained high up the mountain side from places that less than a quarter of a century ago would have been regarded as inaccessible. In the Sagro Valley, the sole quarrying rights of which are owned by a British firm (Messrs. Walton, Gooddy & Cripps, Ltd.), some of the quarries are situate near the summit of the mountain. The larger blocks secured are sleighed down the "Balzone," a slide hewn out of the solid marble for a distance of three-quarters of a mile, with an average incline of 45°. Small blocks are conveyed from the quarry to the saw-mills over a funicular railway, consisting of a double-line aerial cable-way, with a carrying capacity up to five tons. The span of the cable is 700 yds., between supports, the upper station being situate 1,490 ft. above the level of the lower. The carriers are also employed in conveying material for use in quarrying operations to the upper station (see Fig. 30).

The marble, whether in block, slab, or worked material, is conveyed in small coasting vessels to Leghorn, and is thence exported to all parts of the world. The cost of handling is considerable, and increases to a large extent where blocks of three tons and over have to be handled. When the extent of the trading is taken into consideration, it is surprising that arrangements are not made for direct supply from the nearest available port—Avenza.

The amount of marble produced approximates 300,000 tons each year, 80 per cent. of which is exported. Notwithstanding the development of the American quarrying industry, the United States is still Italy's best customer, and takes some 20 per cent. of her output.

Fig. 30.

The Funicular Railway, Sagro Valley, Carrara.

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The demand from Germany is nearly equal to that of the United States, and is followed by Great Britain, 15 per cent; France, 13 per cent; the remainder of the product not required for home use going to countries with lesser demands. It can be said with truth that Italy supplies the world with white marble.

Italian white marble is divided into three grades—Sicilian, Vein, and Statuary. The name "Sicilian" is one peculiar to the English trade, the origin of which is somewhat doubtful. Sicilian marble corresponds with the Bianco Chiaro of Italy, and includes all white Italian marble, the veining of which is cloudy and irregular. The bulk of the marble for the British market is obtained from the group of quarries in the Ravaccione ravine, near Carrara, and the Sagro Valley, in the immediate neighbourhood. Vein marble has a lighter ground than Sicilian, and the markings are more accentuated. The principal quarries are situate in the Canal Grande, Grand Ravine, and at Gioja, Collonata. Statuary is pure white marble, free from spots and veins. The Statuary obtained from Bettolia, near Carrara, while of good appearance, is soft in working, and will not wear well. The best varieties are obtained from Seravezza (see "Uses of Marble," p. 66, etc.). The names of Second Statuary, Bastard Statuary, and Statuary Vein are given to varieties of marble falling between these groups. These are variable in quality, and include all varieties of Carrara, Massa, and Seravezza marbles having a white or statuary ground, with more or less markings. Sicilian is the best marble for hard wear, and is used for treads of staircases, floors, etc.

The other varieties are in occasional use for interior decorative purposes.

The whole of the older quarries are situated on the southern slopes of the Apuan Alps. During the past few years quarries have been opened up in the Equi Valley, on the northern slope of the mountains, where it was known that extensive deposits of white marble were in existence, the marble being shipped from Spezia. The venture has only met with partial success, the marble coming on the market from this source being mostly of a soft and friable nature. It is anticipated, however, that as these deposits are further exploited, the quality of the marble will improve, and a further valuable source of supply be added to the world's markets.

Italy produces a choice variety of coloured marbles. Pavonazzo and Dove are both quarried in the neighbourhood of Carrara. Some of the finest brecciated marbles are secured from the quarries of Piedmont, and the marbles of Siena, Verona, and Brescia are well known and extensively used. Many of the green marbles used in this country are obtained from the Provinces of Tuscany and Curia; and some fine brecciated varieties have recently come on the market from the Calabrian district of Southern Italy, shipments being made from Messina. Extensive deposits of onyx are also available, mainly from the neighbourhood of Tivoli; and Italian alabaster, raised and worked in the neighbourhood of Volterra, is known all over the world. The latter product is often substituted for statuary marble for low-priced ornaments. After the work is completed, it is placed in a vessel filled with cold water, and brought to boiling-point. This has the effect of slightly hardening the surface of the material, and of

PLATE III.

BRECCIA VIOLETTA (SPARAVIZZA, ITALY)

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making it more opaque. Italian alabaster is sometimes sold as "Castellina" marble. Articles worked from this material are often foisted on an unsuspecting public at seaside auction marts and at the so-called forced sales of artistic productions that are to be encountered in London and elsewhere. Volterra alabaster can be distinguished from marble by the fact that it can readily be scratched with the thumb-nail. Its value is about one-fifth of that of a similar article produced in Carrara Statuary.

Fig. 31.

After a Blast, Carrara.

The principal method of extraction employed in Italy is the wire saw, both alone and in conjunction with the penetrating pulley. Large blasts are still resorted to in some of the less accessible places, the masses of rock dislodged being afterwards cut up into transportable blocks. This is done in some cases by means of the wire saw. In some of the smaller of the coloured marble quarries, wedging and the plug and feather system is still resorted to.

CHAPTER VII.

Sources of Production: French and Belgian Marbles.

The quarrying and working of marble in Gallic territory are older than is the French nation. When Gaul was a Roman province, marble was produced from her quarries and fashioned in her workshops, and at least four marbles of Gallic origin were used for decorative purposes in Imperial Rome. Ancient work existing throughout Southern France, executed in native marbles, bears testimony to the durability of the material and the skill shown by the Gallic workmen of olden days. The ecclesiastical architecture of the Mediæval period abounds, too, with instances of marble work of a high order, and with each succeeding period the use of the material was enlarged, and its value for purposes of decoration brought into greater prominence. The industry was encouraged by several of the French monarchs, especially during the time of the French Renaissance, and the State records show several instances of the interest taken by the kings of France in the development of the various marble quarries of the kingdom. Stores were accumulated by the various kings, from Louis XII. onward, and records are existing of several agreements made for the supply of tackle, labour, etc., for the carrying out of contracts in various coloured marbles, the material being supplied from the king's store. Perhaps the highest point in the industry was attained at the time of Louis XIV., in whose reign occurred the building of the Palace at Versailles, the

greater and lesser Trianons, and the king's houses at Marly and Meudon. The stocks of marble that accumulated at this period are said to have been sufficient not only to meet the demand set up by these erections, but were available for the requirements that were in force right down to the time of the Revolution.

The internal unrest prevailing in France and throughout Southern Europe during the First Republic and the Napoleonic *régime* was such that the marble industry, in common with many others, was practically extinguished, and it was not until 1835 that an upward movement was perceptible. Since this date the prosperity of the marble trade in France has been a continually increasing one. The majority of the older-known marbles are again quarried, and many new deposits have been exploited, and are available for present-day requirements. In a list of one hundred of the marbles best known to commerce, prepared by Mr. Arthur Lee in 1887,* no less than thirty-two were of French origin, and many new varieties have since then come into use, and are now on the market.

The most prolific of the marble-yielding provinces are to be found on the southern borders skirting the Pyrenees. The Haute Gironde, Hautes Pyrénées, and Pyrénées Orientales, are all of them rich with marble-bearing strata, as are the Provinces of Ariège, Var, and the Hautes Alpes. Some fine breccias are quarried in the neighbourhood of Molinges, Jura; one of the richest-coloured of red marbles comes from Aude; many varieties of Brittany marble are obtained from Mayenne and Sarthe; and a number of unicoloured marbles come from the Pas de Calais district.

* "Marble and Marble Workers," Ch. 12, p. 122, etc.

The French colonies of Tunisia and Algeria produce some exceptionally fine marbles, which, though small in number, are largely used throughout Europe and America. These are generally known as "Numidian" marbles, some of them being identical with the marbles thus known to the ancients. The principal Algerian quarries are situate in the Montagne Grise, some 20 miles north-east of Oran, from which port they are shipped. The colours range from the rich yellow of Jaune Antique to the brilliant red of Brêche Sanguine. The neighbourhood is of interest on account of the traces that remain of the old workings. Blocks of stone are here to be seen which were extracted nearly 2,000 years ago, and the original grooves and wedge holes for further extractions are also in evidence.

The deposits of marble found at Chemtou, in Tunisia, are of great value. One of these is the Giallo Antico of ancient Rome. Portions of the road constructed by Hadrian (A.D. 128–9) for the conveyance of the marble from the quarries to the Port of Tabarca are still existing. Blocks are now put on rail at Oued-Meliz, and shipped at Bona or Tunis.

Onyx marble is also obtained from Algeria, the principal quarries being situate at Ain Tecbulet, near Tlemçen. While of less brilliancy than the American varieties, Algerian onyx is of great beauty, and is extensively used for decorative purposes, also for high-class furniture and ornaments. A brilliant red variety of onyx has recently been located in this district, and is now on the market.

The methods of extraction most prevalent throughout France are the wire saw and wedge and drill work in combination, explosives being used in but exceptional

cases. Channelling machinery of light build has been tried to a small extent, but the results obtained have not justified its retention.

Belgian Marbles.—The marble industry of Belgium is a practical illustration of how energetic working and perseverance will enable a country that is far from rich in a particular product to take hold of the material and make the trade therein her own. The marbles produced in Belgium are generally of an inferior grade, but they have been well exploited, and are perhaps better known than the greater number of the choice varieties. Nor is this all. Belgian firms are among the largest workers of marble, and are the principal workers for the British market. While the bulk of the marble exports to Great Britain shows a large turnover, it is probable that considerably over one-half of the declared value and one-third of the tonnage represents marble of French, Italian, Greek, etc., origin. One firm alone has a turnover in Great Britain approximating £60,000 per annum, and although the proprietors are themselves extensive owners and workers of Belgian marble quarries, they admit that nearly two-thirds of this amount represents marbles of foreign (*i.e.*, other than Belgian) origin.

The principal Belgian marble deposits are of Devonian and Carboniferous Age. They are not of handsome appearance, and are seldom used for decorative purposes, the bulk of the supply being utilised for cheap shop-fitting, table-tops, and sanitary work. The carboniferous formations are exceptionally sound—in fact, Belgian Black is one of the best, and is certainly the most extensively used of all black marbles. Another variety, misnamed Belgian "Granit," is largely used for building purposes, and has

been employed to a small extent for this purpose in London, Bristol, and elsewhere. Bleu Belge, or Belgian Grand Antique, is in considerable demand for skirtings, etc.; and Saint Anne's—a dark grey, nearly black marble, with light grey markings—had at one time the reputation of being the soundest coloured marble existing. This distinction it now shares with other productions. The red marbles are sold under high-sounding names—Rouge Imperial, Rouge Royal, Rouge Byzantine, Rouge Fleuri, etc.—but there is little distinction between them, save that of the colour tone, which varies from a brownish red, with white crystalline veins, to a washed-out, light brown shade, with white and grey patches and irregular, broken veinings. The better varieties are sound, and are available for interior constructional work, as at the London City and Midland Bank, Birmingham, where columns of this material are employed; but, ordinarily, "Rouge" is a table-top or underground convenience marble, capable of relieving Sicilian occasionally in a counter-front or shop-fitting, and mainly used because it is cheap. The soundest of the Belgian Rouges is the variety known as "Rouge Griotte."

An exception should be made of "Rouge de Rance," which, while being of similar formation to other Belgian Rouges, is rightly classed as a decorative marble. The markings are somewhat heavy, but a combined effect of brilliance and solidity is obtained by its use. The Rance quarries were reopened in July, 1900, after being closed for nearly 200 years. One of the last contracts previous to closing was the supply of blocks for the large columns for the Palace of Louis XIV. at Versailles, then in course of construction. The reopening was for the

purpose of securing 120 monolith column blocks for use in the construction of Antwerp Railway Station. This marble is mentioned in Neve's "Builders' Guide" of 1736 as being in use in England for chimney-pieces. A handsome breccia is secured from Hastières, near Dinant. The surface presents a bewildering variety of colours—

Fig. 32.

A Block of Rance Marble as Quarried.

black, red, brown, grey, pink, and white being mingled in fragments of all shapes and sizes.

The principal deposits of Saint Anne's marbles are in the neighbourhood of Gougnies—where a deposit exists over 6 miles in length, 60 ft. in width, and 100 ft. in depth—and at La Bussière, near Erquellines. The latter deposits are of lower quality, and are in less demand.

Rouge is mainly obtained in the neighbourhood of Philipville.

The methods of quarrying in force in Belgium are among the finest in Europe, and the leading Continental manufacturers of quarrying machinery being of Belgian establishment—principally in the neighbourhood of Namur and Charleroi—the first application of new processes is often made in Belgian quarries. The wire saw is in general use, sometimes in conjunction with the penetrating pulley, and in some instances working in shafts sunk by revolving drills of hollow sections of from 2 ft. to 4 ft. in diameter. These permit of the core being extracted intact—practically a roughed-out marble column (see Fig. 14).

The facilities both for quarrying and handling the material are suitable to the deposits, and are well managed. In the Petit Granit quarries, at Soignies, the deposits are in layers of (*a*) Soil covering varying from 6 ft. to 30 ft. in depth; (*b*) Bad rock, known as *raches*, and utilised for hydraulic lime, 30 ft. in depth; (*c*) Building stone, 15 ft. to 20 ft. in depth; (*d*) Best quality stone, suitable for marble purposes, and having an average depth of 75 ft. An earth seam, 2 in. thick, separates the bottom layer from that immediately above it. This is named "*délit à la terre.*" The beds incline at an angle of 12°. The appliances in use include Ingersoll rock drills, for breaking out the *raches*. This is effected by means of explosives, the good beds being worked by the plug and feather system. The wire saw is used for working the lower beds, the sinkings for the pulleys being made by circular drills, making holes of 3 ft. diameter and 13 ft. deep. The size of the blocks secured are only limited by the capacity of the lifting machinery. This includes three 60-ton capstans,

for hauling blocks to the surface by means of an inclined plane, and a rolling bridge or travelling crane of similar capacity. These are worked by electrical power. The smaller blocks are removed by steam cranes of less capacity. All of these appliances are in operation at the

FIG. 33.

PETIT GRANIT QUARRY AT SOIGNIES, BELGIUM.

Perlonjour quarries, Soignies, the output of which averages over 50,000 tons yearly of marble and building stone. Petit Granit is quarried at Maffles, Soignies, Eucassines, and Feluy-Arquennes, in the Province of Hainaut, also in the valleys of the Hoyoux and Ourthe rivers, in the Province of Liège. The material obtained from the Ourthe Valley is more highly esteemed for employment as

marble, the principal use of the output from other centres being for building purposes. Petit Granit is in extensive use in leading Belgian towns, and is largely exported to France, Holland, and Germany.

The principal deposits of black marble are situate in the neighbourhood of Golzinnes, north of Namur. The formation extends for some 8 miles from Villaret-sous-Saint-Martin-Balâtre, through Mazy and Golzinnes to Isnes-Sauvages. The deposits are from 30 ft. to 40 ft. in depth, and incline at an angle of 18°. The marble beds occur in regular layers, which are separated by a bituminous shale of no value. They vary in thickness from a few inches to 4 ft., the deeper beds—which are of best quality material—being on the lower levels. All the beds are quite free in working.

The nature of the formation necessitates mining, rather than quarrying, being resorted to in order to secure the better qualities of marble. The workings follow the dip of the formation, which is extremely regular. Blocks are loosened from the rock by means of explosives, and afterwards broken up with bars, large pillars being left to support the roof. The blocks are hauled to the surface by an inclined plane, the winding machinery being driven by electricity. The presence of water adds to the difficulty of securing material, and in one quarry known to the writer, the depth of which is over 250 ft., pumps having a capacity of 1,750 cubic ft. per hour are in operation. Belgian Black is an exceptionally hard marble, and most difficult to work for those unacquainted with its peculiarities. The marble has an exceedingly fine grain, and takes a splendid polish. It is supplied in four qualities—best, second best, common, and inferior.

CHAPTER VIII.

Sources of Production: Greek Marbles.

The introduction of Greek marbles into Great Britain, other than as works of antiquity, practically dates from 1896. Previous to this date, the only Grecian marble available for export was obtained from the deposits of Rosso Antico, at Lageïa, the ancient quarries here and at Cynopolis, Damaristica, having been rediscovered some ten years earlier. The Verde Antico deposits were located by Mr. W. Brindley in 1889,* no less than ten ancient quarries being found. The marbles secured show every shade and variety of Verde Antico as seen in the buildings of ancient Rome and Constantinople, as well as some extremely rare greens seen in the Vatican and Louvre Museums, and till then attributed to Egyptian origin. After prolonged negotiations, a concession was obtained to extract the material, and in 1896 the Verde Antico Marble Company was formed, with a capital of £20,000, to work the quarries on systematic lines. Primitive methods of extraction have given way to working on modern lines, the wire saw being the mode of extraction in most general use.

Verde Antico, whether as a constructional (interior only) or decorative medium, occupies a status peculiarly its own. The colour tones and formation of the marble are unique. The deposits admit of blocks being secured

* See Transactions of R.I.B.A., Series III., Vol. III., p. 267.

to any dimensions within reason, and the output is, as it deserves to be, an increasing one.

The Pentelikon deposits were reopened in 1834, after nearly 1,500 years of disuse, the occasion being the

FIG. 34.

A PENTELIKON QUARRY.

erection of the palace of King Otho at Athens and various government buildings. A period of depression ensued, and it was not until 1861 that the quarries were again in active work, when over 7,000 tons of the material was used in the erection of the Academy of Science. This

was followed by the Polytechnic School, the Central Museum, the Parliamentary buildings, etc., and although difficulties existed in developing an export trade, the output of Pentelikon marble was a continually increasing one. Blasting, with its accompanying large proportion of waste, was generally resorted to for the extraction of stone, and the roads from the quarry were in bad condition; and when a further period of trade depression set in, the quarrying of marble was well-nigh abandoned. In 1897 the Anglo-Greek Marble Company, now known as Marmor Limited, was formed, with a capital of £350,000, to purchase the quarrying rights on Mount Pentelicus and elsewhere in Greece, and develop the quarries on systematic lines. Railways have been laid down, roads constructed, and modern appliances for quarrying utilised to the full, with the result that Pentelikon marble is now known and used both in the leading cities of Europe and the United States. The company has also secured the freeholds of the marble deposits in Paros, Tinos, Skyros, Naxos, Eubœa, etc., and may be correctly described as being the largest individual firm of marble quarry owners in Europe.

Reference has already been made to the use of Pentelikon marble for building purposes. The coloured varieties owned by the company are of no less importance for their decorative effect. Greek Cippolino, Tinos, and the varieties of Skyros, are all of them marbles of exceptional beauty; and when to these are added the products of the Rosso Antico * and Verde Antico quarries, it is

* Marmor Limited also own and work extensive deposits of Rosso Antico at Mani, Laconia.

Fig. 35. Stacks of Greek Marble for British Use, Crabtree Wharf, Hammersmith.

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SKYROS No. 14A (GRECIAN ARCHIPELAGO)

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probable that Greek marbles will take an even more prominent place in the decorative architecture of the future than has obtained in the past. The yield of all the varieties is prolific, the quarrying methods are of the best, and the facilities for the supply of the material are most complete. Considerable stocks of all of the marbles mentioned are maintained not only at the quarries, but in London and various European centres, so that supplies are readily available for all ordinary demands.

One of the advantages claimed for Greek marbles is that they are of themselves sufficient for the highest decorative effect. The colouring of the respective marbles blends in a harmonious manner, and an effect of richness is produced by their use unattainable in any other medium. The hold that other varieties have obtained, however, is too great to be easily overcome, and much remains to be done ere the Greek productions will fill the position desired by their proprietors.

The exploitation of Greek marbles will probably have a considerable effect on the British marble industry. Not only is British capital mainly engaged in working the quarries, but the material is, on account of the conditions governing its transport, as readily obtainable in British as in French, Italian, or Belgian ports, and at at least equal cost. The quarry owners are not workers of marble, apart from the securing of blocks to required sizes, and, given slight encouragement, the development in the working of the many varieties of Greek marble in Great Britain should, apart from its use for constructional purposes, be considerable.

CHAPTER IX.

Sources of Production: Various.

While valuable deposits of marble are known to exist in various parts of the world, the conditions governing their production and transport are such that many of them are not commercially available, and the interest taken in them is, from the marble worker's and user's standpoint, academic rather than practical. This will apply to a number of German marbles; the deposits in the Ural Mountains; the marbles of Asia Minor, India, Persia, and Egypt; also to many of our Colonial marbles, which, though valuable from the local architects' standpoint, are of no commercial interest until they enter into active competition with varieties at present supplied.

The European countries, in addition to those already referred to as producing marble for British use, are Spain, Portugal, Switzerland, Austria, Norway, and Sweden. These, with small quantities from America, constitute our available sources of supply.

Spain.—The marble deposits of Spain are known to be of great variety and richness, but few of them are quarried for even local requirements. Of the forty-two varieties identified as having been used in Imperial Rome, four were of Spanish origin, and fragments of marble of native origin have been discovered among the ruins of ancient Merida, which was built B.C. 28. The uses of marble were known and realised in Moorish architecture, and reference to work of the Middle Ages shows that at

one time the industry must have been in a flourishing condition. It has been stated that the Mosque of Cordova, erected by Caliph Abdoulrahman III., is ornamented with 1,200 marble columns, and that the vault of the Toledo Theatre is supported on 350 marble columns, the greater number of which are of Spanish origin.* These, together with the many examples of ecclesiastical architecture in the principal cities of Spain, give some idea of the extent of the industry in bygone days. Little is done in this direction now. With the exception of an occasional block of Spanish Brocatelle, a small quantity of red marble from La Bouceau, and a brown marble of recent introduction to which the name of St. Katherine has been given, Spanish marbles are, so far as the British market is concerned, a negligible quantity. The rouge marbles of St. Sebastian and Carrica are being introduced on the Continent, but have not, up to the time of writing, been used in this country to any considerable extent.

The only development of interest that is taking place is the exploitation of the white marble deposits in the Sierra Felabres, near Almeira. This formation is of great extent, and is described by Don Vincente Cuervo, of Madrid, as "another Carrara as yet in a virgin state." The deposits cover a large area and are of great depth. Until 1905 only a few communal properties near Cobdar and Macael, the right to work which belonged to the local inhabitants, were being worked; but a British company was formed in June, 1906, under the title of "Spanish Marbles Limited," with £25,000 capital, to take over and develop the principal marble deposits in the district, and to apply

* "Marble and Marble Workers," p. 73.

Fig. 36.

Marble Quarrying in Spain (Macael).

Note the overhanging screen of bushes as a protection from the glare of the sun on the marble.

modern methods of extracting and working the marble. These have already resulted in a considerable increase in the marble produced, some 8,000 tons having been shipped from Aguilas in 1907. With improved facilities for quarrying and transport already in hand, the output, the whole of which is at present taken for building purposes at Madrid, Barcelona, and other Spanish towns, will soon be sufficient to more than satisfy existing demands. This will necessitate outside markets being secured, and a regular export trade instituted. In this event, the British market will be one of the first to be sought, and the progress of the venture is being watched with interest. The writer has had opportunities afforded him to examine the material. It is of exceptionally close texture, the crystallisation being slightly coarser than that of Sicilian marble, while it is rather harder. It takes a good polish, the surface closing well, and is entirely free from veins or prominent markings. While its hardness will probably militate against its use for carved work, the marble should be specially suitable for building and electrical purposes, and should be generally available for the various uses for which Sicilian and Pentelikon marbles are now employed.

Portugal.—The marbles of Portugal are of considerable number, but very few of them are known outside the localities in which they are found. The marbles obtained from the Pedro Furanda quarries are used extensively for building purposes in Lisbon and neighbourhood, and considerable quantities of these marbles have been exported and been employed to advantage for decorative purposes. The varieties are known in England by the names of Emperor's Red, Corallo, and Vedrasse. While the deposits of marble are

of considerable extent, the methods of extraction are primitive. No machinery whatever is employed, the blocks being separated from their beds by driving wedges between the veins with heavy hand hammers. Only surface quarrying is in force, the beds not being worked beyond 4 m. (13·4 ft.) in depth. The colour varies from a bright coral red to a creamy flesh tint, the latter variety containing large fossils of even shade. Blocks are obtained up to 6 tons in weight, and the marble is sound and of good appearance. A marble of handsome appearance is quarried near the town of Villa Nova d'Ourem. The ground is flesh-coloured, interspersed with broad, white crystalline veins and a network of fine, red veins. The marble is known as St. Sylvester. It is one of the soundest of coloured marbles, can be obtained in large blocks, and takes a brilliant polish. Unfortunately, the demand for the marble is insufficient to keep the quarries in constant employment. The supply, therefore, is irregular.

Quarrying methods generally throughout the Iberian Peninsula are primitive. The wire saw is in operation at St. Sebastian, and in the properties of Spanish Marbles Limited there is an extensive installation, both for quarrying and working the material. This includes wire and diamond saws, besides special plant for sawing slabs, etc. Elsewhere wedging and hand drilling are the ordinary modes of extraction.

Switzerland.—The only Swiss marble used in Great Britain is a variety of Cippolino quarried at Saillon, near Saxon, in the Valais Canton. Previous to the introduction of Greek Cippolino, this marble was in considerable demand, but when the more handsome variety was placed on the market, Swiss marble was no longer in favour. Recently

the marble has again come into prominence, and its use is on the increase. The quarries are able to produce sound column blocks in large sizes, but delay is sometimes encountered in securing deliveries.

Austria.—The best-known varieties of Austrian marble come from the Province of Istria. This marble was extensively used in the Venetian architecture of the fifteenth century. It is a unicoloured marble of a creamy shade, and has been used to some extent in this country. The porphyries and serpentines of the Tyrol are in large demand for local decorative work.

Norway.—The supply of Norwegian marbles is practically confined to the Dunderland deposits occurring some 150 miles north of Trondhjem. The deposits extend for considerably over a mile, and are estimated to be over 1,000 yds. in depth. The Dunderland marbles are distinguishable by an exceptionally coarse crystallisation and by the entire absence of veins, the various colours appearing in the formation occurring in stratified form. No trace of lamination is, however, apparent, and the material is exceptionally sound. The colours range from pink to dark green, considerable quantities of pure white also occurring. It is most difficult to work, and will not take an even polish. In connection with this point, the writer remembers an amusing incident. Columns of Norwegian marble were supplied for the interior decoration of the pavilion at Antwerp Zoological Gardens (1899-1900). The City Fathers were not satisfied with their appearance, and made inquiries as to what could be done to improve the surface of the marble. The columns had been imported in a worked state, and the trade generally, resenting this action, declined to interfere or even make a

suggestion. In the end *it was decided that the columns should be varnished!*

Sweden.—The only marbles in use in Great Britain of Swedish origin are quarried at Marmorbruket, near Norrköping, and have been worked in a small way since 1650. Following the adoption of modern methods of extraction and working in 1902, the material has been made available for general use, and has been very favourably received. The colour tone ranges from light sage green, mottled with white, to a somewhat deeper tone, with flowered markings of dark olive. Swedish Green is a very sound marble, and is procurable in large sizes. It is of close texture, and takes generally a good medium polish, without brilliancy

FIG. 37.

A SWEDISH MARBLE QUARRY, MARMORBRUKET, NEAR NORRKÖPING.

of surface; some varieties, however, take a high polish. The crushing strain of the marble is given as 925 kilos per square cm., corresponding to 5·88 tons to the square inch, and in abrasive tests a superiority of 20 per cent. over Italian white marble was shown. While not of itself of a strikingly decorative appearance, Swedish Green gives a pleasing effect when used in interiors, and is employed to considerable advantage as a foil to marbles of great brilliancy of colour tone. It is especially suitable for floors and places where hard-wearing qualities are required, and should also be available for building purposes and exterior decorative work. Its employment in this connection at the new Egyptian Hall, Piccadilly, W. (erected in 1907), will be followed with interest. With certain of the earlier consignments of this marble a tendency to fade on exposure to a strong light was apparent. The quality of the marble has, however, improved with the greater depth at which the quarries are worked, and this defect has practically disappeared. A pleasing contrast can be obtained, when using Swedish Green, by having block sawn in opposite directions—with and across the natural bed. Previous to 1906 the marble was extracted by drill and wedge methods; a wire saw installation has since been erected, and is in regular use. Pneumatic machinery is largely used for the subsequent working of the material.

The United States of America.—The marbles raised in the United States of America are of great variety. The material is used to a much greater extent for building purposes than is the case in Great Britain, partly on account of the climatic conditions being generally more favourable to such use, and partly for the reason that

American architects are less hampered by considerations of first cost than are their British compeers. Buildings containing close on a million feet cube of marble are not uncommon, and the quarrying and working of marble is consequently an important industry.

The principal marble-producing areas are Rutland, Fowler, and Proctor (Vermont), where a variety of white marble, somewhat similar in formation to Sicilian, is raised, also a light blue marble, similar in appearance to Italian Dove, as well as several varieties of veined marble; Dover (New York); West Grove (Pennsylvania); Tescar and Cockeysville (Maryland); Knoxville and Chattanooga (Tennessee); Birmingham and Sylacagua (Alabama); and Tate (Georgia). Onyx marble is obtained from the States of Arizona, Wyoming, and California.

The only American marble (apart from onyx) used to any appreciable extent in this country is a variety of Vermont marble known as "Listavenna." This was first introduced by Messrs. Burke & Co. for the interior decoration of the Criterion Restaurant in 1900, and has since been employed in several buildings in the Metropolis. One of the best instances of its use is in the main office of Messrs. Dewar's buildings, Haymarket, S.W. (1908), the large wall panels being of this material (see Fig. 69). The light brown marble used in the dado at the Criterion Restaurant is also of American origin.

The onyx marbles obtained from Yavapui County, Arizona, rank high among decorative materials. The formation is described by Dr. G. P. Merrill as "a carbonate converted into a more or less hydrated oxide by the action of percolating solutions, whereby the green is changed to

red, brown, or amber-yellow colours in all shades. . . . All stages of the process are seen at the various openings, from those in which the green stone is covered with a mere crust, and scarcely sufficiently veined to give a desired variety, to those in which scarcely a trace of the original green remains, but the whole block is a red-brown colour in varying shades. . . . The colours are rich but not gaudy, and when properly prepared, are capable of effects both unique and beautiful. There is in the National Museum at Washington a stone of brown and red colour so cut with the grain as to resemble, in a wonderful degree, a piece of antique tapestry. The details of its structure are intricate in the extreme, and, since what is to be seen by a careful study of them depends almost entirely on the vividness of one's imagination, the writer drops the subject, to be taken up, it may be, by those more gifted in imagination or in the faculty of description. . . . The compact, highly lustrous green stone, with a surface almost as close as enamel, and with its veins and dashes of red and brown, is, however, the most desirable of all."*

Arizona (Yava) Onyx was introduced into Great Britain in 1904, and has been received with favour. While the supply was irregular in the first instance, large stocks of the material are now maintained, and there is little doubt that this medium of decoration will be used to a large extent as it becomes better known.

The only public building in this country, so far as the writer is aware, where Arizona Onyx has been employed

* "Stones for Building and Decoration," p. 265.

Fig. 39.

ARIZONA ONYX.

Interior of National Provincial Bank, Aberystwith.

The Architraves, Pilasters, and Dado are of Arizona Onyx, with Skyros (purple veined) Wall Linings.

is the National Provincial Bank building at Aberystwith (see Fig. 39). It has also been used for the decoration of several private house interiors.

Wyoming Onyx is of a deep brown colour, with markings of lighter shade, having some resemblance to large fish scales. Californian Onyx is of light green ground, sometimes mottled with white, and with red and amber-yellow veins traversing the surface.

The principal deposits of Mexican Onyx in ordinary use are situated in the district lying south-east from Puebla, the finest varieties being obtained from the La Pedrara quarry, some 20 miles from Puebla, and at St. Antonia, near Vera Cruz. The opening up of the country has, however, brought other deposits into prominence. Beds of onyx have been located near Magdalena, on the Mexican and Southern Railway, surpassing both for size and quality anything previously obtained. The colour tone ranges from a deep green to a light clouded green of great delicacy, and the veinings from red to bright yellow, the whole producing a decorative effect of extreme richness. The sizes of blocks that can be obtained are only limited by the facilities available for transport, and the entire deposit is of high grade. Several blocks of this material were on exhibit at the Mexican Exhibition held in the Crystal Palace in 1908, and arrangements have since been made for exporting the material to this country, blocks up to 60 cubic ft. in dimension being, at the time of writing, *en route*. The quarries are situated over 250 miles from the most available seaport (Santa Cruz), and the cost of transporting and shipping the material will considerably add to its cost. Brazilian Onyx is of great

beauty. The ground colour is deep green, the surface being marked with brilliant red veins. All the varieties are translucent. While the greater part of the output of good quality onyx is exported to the United States of America, all the varieties are used to no inconsiderable extent both on the Continent and in this country.

Generally speaking, American marbles, the varieties of onyx excepted, are not at present commercially available for use in Great Britain. There are few varieties that can compare for decorative effect with the marbles of Greece, Algeria, the French Pyrenees, Italy, or Brittany. The cost of quarrying is much higher than that prevailing in Continental centres, and when transport charges are added, the prices at which blocks can be secured are so high as to make competition extremely difficult. Consequently, where American marble is used, it is mainly on account of some delicacy of tone found in a particular variety, and for which the architect, or his client, is prepared to pay. The home demand for marble, both for building and decorative purposes, is sufficiently large not only to absorb the American output, but also to draw largely on European quarrying centres for further supplies. Owing, however, to the high tariff rates that are in force on manufactured or partly manufactured work (see pp. 151–2), importations into the United States, works of art excepted, are mainly restricted to marble in block.

CHAPTER X.

Sources of Production: Marbles of the United Kingdom and British Colonies.

THE marbles raised in Great Britain are of great variety, and, with the exception of white marbles, are capable of being produced in sufficient quantity to satisfy the greater part of our requirements. They have been worked considerably in bygone days, when marble was much less used than is the case to-day. Thus, Hollingshed, writing in 1577, states: "Many marbles are there in England, but chiefly one in Staffordshire. Of white marble also we have store. The black marble, spotted with green, is none of the vilest sort." Hutchings, in his "History of Dorset," written in 1724, mentions that "in Purbeck there was formerly dug marbles of several colours—blue, red, spotted, and grey, but chiefly the latter—all of a coarse sort." Polwhele, in his "History of Devonshire," states that "there are twenty-four known varieties of Devon marble"; and Sir Henry de la Beche, in his "Report on Devon, Cornwall, and West Somerset," says: "Marbles of very great variety may be obtained, though tints of grey chiefly prevail, and they deserve to be far more extensively employed than they have hitherto been; a greater demand would cause more varieties to be worked."

One of the reasons why British marbles are not employed to a greater extent may be briefly referred to. The principal sources of supply of worked marble have, until recently, been Belgium and France, and, with material ordinarily in use in these countries readily

obtainable, it has not been in the interests of foreign manufacturers to introduce British marbles. Besides, the demand being a comparatively limited one, British quarry owners have not been in the habit either of quarrying on modern lines (a system that is only economical where there is a constant demand), or of accumulating stocks from which supplies might be obtained. There are many deposits of marble of good quality and handsome appearance that are only worked for two or three months in the course of the year; hence, when work is contemplated, a marble is specified that can be supplied in less time than would be required for one of British origin.

Another point that assists in curtailing production is the excessive freight on our home railways. The cost of bringing marble in block from either Derbyshire or Devonshire to London (quarry to railway depôt) is higher than for bringing it either from Italy or Belgium (quarry to port), although in the latter instance the railway mileage amounts to considerably more than half the distance mentioned; and when to this is added the amount of waste on which carriage has to be paid, due to inefficient quarrying methods, it will be seen that the British marble industry is severely handicapped. For all practical purposes, the trade has been in the hands of foreign firms (Belgian and French) supplying indirectly through British houses, who have recommended for use the marbles that were best available, *i.e.*, those of which they either held considerable stocks or had partial or entire control. How best to alter these conditions, and foster a home industry for which we possess distinct natural advantages, is a matter of considerable difficulty.

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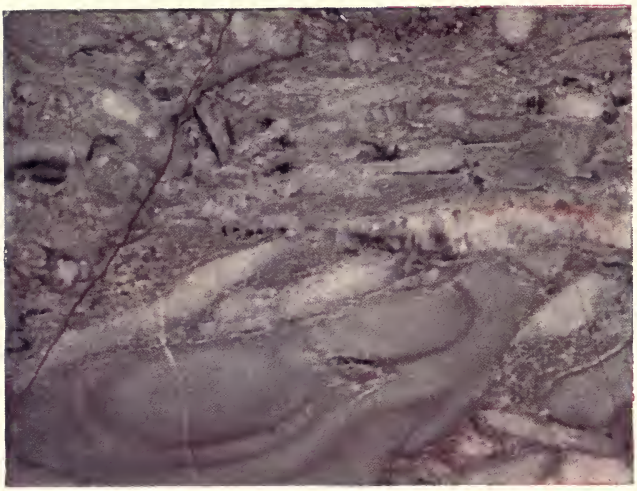
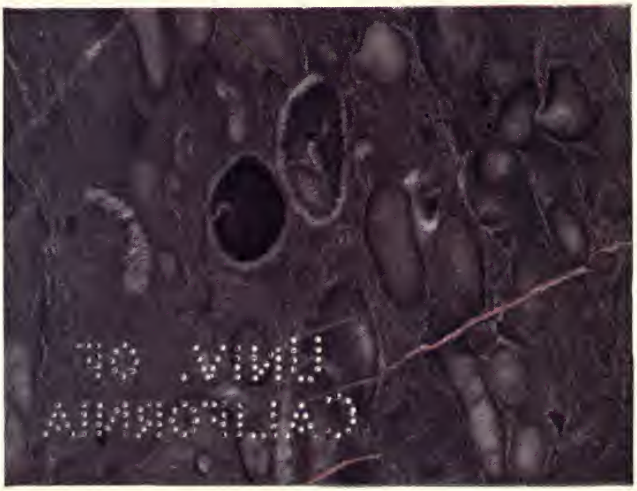
PLATE VI.



PRINCE ROCK GREY



FAVOSITIDÆ.

DEVONSHIRE MARBLES.

[*To face p.* 105.

A tariff on worked marble has been suggested as being likely to encourage not only the working of marble in this country, but also the development of our native resources. While opinions are divided on this point, it is significant to note that the great development that has occurred in the quarrying industry of the United States of America has followed the imposition of a tariff on imported material,* varying in amount with the proportion of work that has been expended on its preparation, and that similar progress is taking place in Germany, the last of the European countries to adopt a protectionist *régime*, although in the latter instance unworked stone is admitted free of duty.

The principal marble-producing areas in the British Isles are Devonshire, Derbyshire, and Staffordshire in England, Sutherlandshire and the Western Hebrides in Scotland, and Galway and Kilkenny in Ireland.

The marbles of Devonshire possess a beauty distinctively their own. They occur mainly in the Middle and Upper Devonian Period of Paleozoic time, and are among the older of the marble formations. The varieties produced range from light pink and yellow to dark grey, almost black, some of the red varieties being of great brilliance. The silent evidence respecting their age presented by the fossil markings of certain of the varietics is of interest both to geologists and paleontologists. The district from which the marbles are obtained ranges from Newton Abbot to Plymouth, and inland to Chudleigh and Ashburton. A grey marble streaked with red is found

* The tariff on rough marble entering the United States is 65 cents per short ton, or less than $2\frac{3}{4}d.$ per foot cube. For further particulars respecting the American tariff, see pp. 151–2.

at Ipplepen, and a more handsome variety at Silverleigh; a light red variety at Stonycombe, near Kingskerswell; a bright red at Ogwell; the Petitors, yellow, clouded and grey, at Babbacombe, near Torquay; a dark grey, with red and white veins, at Ashburton, with a somewhat

FIG. 40.

A BRITISH MARBLE QUARRY, ASHBURTON, DEVONSHIRE.

lighter variety at Chudleigh; a rich-coloured red, with large fossils, at Radford; and several red and grey marbles in the neighbourhood of Plymouth. These include the White and Crimson-veined Black; Devon Sienna, the Spangled Devon Spars, and Favositidæ, with its fine fossil

markings. The methods of extracting marble from the beds are of a primitive nature. Blasting is often resorted to, with the result that the force of the explosives used has a tendency to shatter the stone, causing vents to be developed when it is sawn into slabs. This gives to Devonshire marbles a reputation for unsoundness which is largely undeserved. With improved quarrying appliances, it is possible to secure sound blocks of good quality, and the material only requires to be wider known to meet with the success it deserves.

The principal Derbyshire marbles are Hopton-Wood and Derby Fossil, both quarried in the neighbourhood of Wirksworth. Hopton-Wood is a unicoloured marble, ranging in shade from a creamy white to a medium-toned grey. It can be obtained in large sizes, blocks of 20 tons and over being not uncommon. Birdseye marble is quarried in the same locality. The colour ranges from grey to dark brown, interspersed with grey crinoidal fragments. Derby Fossil is a dark grey marble, containing a large number of encrinites lying at all angles. Black marble is quarried in the neighbourhood of Ashford. The beds are shallow, and the marble, while being of exceptionally close texture, is much more expensive than the Belgian variety, besides being more difficult to work. A marble known as Rosewood is quarried near Ashford, the name being given it on account of the peculiarity of its markings. The Derbyshire marbles are chiefly of Carboniferous Age.

Marble from the lower beds of the Hopton-Wood formation is sometimes used for exterior work. The close texture of the material offers a high resistance to smoky atmospheres, and the surface is practically non-absorbent

Fig. 41.

Carved Panels in Derbyshire Marble, The Moot Hall, Wirksworth.
(Photographed in October, 1908.)

and unaffected by local chemical influences. An instance of this may be observed in the York City and County Bank building, situate in the centre of Sheffield, and erected in 1900–1. The elevation above the first-floor level is executed in Hopton-Wood, and a careful examination of the exterior shows no trace either of disintegration or of absorption of atmospherical impurities. The colour tone is retained throughout, and the building presents a marked contrast to others in the immediate vicinity, the fronts of which have become blackened from exposure. The material appears to be most suitable for use for building purposes in large centres of population, where the majority of building stones either disintegrate or speedily present a grimy appearance.

With regard to the weathering properties of Hopton-Wood, the front of the Moot Hall, Wirksworth, contains three panels (two of them carved in relief), dating from 1818. The detail is as clear as when first executed, and the characteristic markings of the marble are readily identifiable from a photograph (see Fig. 41). The material has been employed in London for the pedestal of the Gordon Memorial in Trafalgar Square, W.C., erected in 1905, and for window-sills, jambs, and heads at 47, Belgrave Square, S.W. At the time of writing it appears to have weathered well. Hopton-Wood is a suitable material for interior work, whether constructional or decorative, being available either for masonry or as a veneer of thin slabs. The distinction between the light and dark varieties is sufficiently pronounced to afford a pleasing contrast, and as the surface does not take a brilliant polish, the subdued effect secured by its use is chaste rather than ornate.

Alabaster is found in Derbyshire and Staffordshire, the principal deposits being at Fauld, near Tutbury. The Derbyshire deposits are mainly worked for the manufacture of plaster of Paris, and as sound, well-figured blocks are secured, they are set aside for sale for purposes of decoration.

FIG. 42.

VIEW IN IONA MARBLE QUARRY, WESTERN HEBRIDES.

The marbles of Iona and Tiree are among the latest British productions—that is, for general use. The colour tone of the former is a delicate shade of green, with white markings, and as a decorative medium it is most effective. Tiree marble shows a variety of colouring, from dark olive-green to brilliant red. Both of these marbles are of serpentinous formation.

Red and green varieties of serpentine are quarried in

the neighbourhood of the Lizard Point, Cornwall. The material presents a handsome appearance when polished, and at one time was in great demand. A variety of greenish-brown serpentine, with small red markings, is quarried at Polyphant. It can be obtained in medium-sized blocks, and is one of the soundest of the Cornish decorative stones.

Other varieties of marble produced in Great Britain are Frosterley, a dark grey fossiliferous marble of attractive appearance, quarried at Harehope, Durham; Purbeck, a light green shell marble, quarried near Swanage; Petworth, or Bethesden, a blue-grey shell marble, quarried near Petworth and at East Grinstead, Sussex; Anglesea, a brown veined marble, quarried at Penmon, near Beaumaris; Lucerta, a dark grey unicoloured marble, quarried at Keinton Mandeville, Somerset; and Furness, a sound marble of similar appearance to Hopton-Wood, quarried in the neighbourhood of Dalton-in-Furness, Lancashire. Besides these there are a number of marbles in various parts of the country (including a deposit of white marble of good quality in Sutherlandshire) that are undeveloped for lack of enterprise, or that are only worked at rare intervals for local purposes, and that are barely known outside the districts where they are raised. For instance, there are in the Museum of Practical Geology, Jermyn Street, S.W. (a building the contents of which deserve far more attention from marble users and workers than at present obtains), two inlaid table-tops containing a number of varieties of Devonshire and Staffordshire marbles of great beauty. Many of these exist in workable deposits, but their production has lapsed, and valuable material is thus, for the time being, lost to the world.

FIG. 43.

FROSTERLEY MARBLE COLUMNS, NORWICH ROMAN CATHOLIC CHURCH.

Irish Marbles.—The marbles produced in County Cork vary in colour from light red with white mottlings to a speckled brown with small white veinings. Cork or Victoria Red is extensively used in Great Britain, and was selected for lining the staircases at the recent extensions of the London Stock Exchange. Black marble is found in County Kilkenny, which also produces a fossil marble. Kilkenny marbles are in considerable demand for local building and monumental purposes. The fossil marble has also been exported to a small extent.

The serpentinous deposits at Connemara are in great demand. These comprise some of the most beautiful varieties of green marble existing, and have been used to a large extent both in this country and in the United States. The shades of green vary from that of olive to light sage, and the marble is in parts translucent. The principal quarries are situate at Recess, Streamstown, and Lissoughter. The best blocks are secured from the Recess quarry, a large proportion of the product being exported to the United States of America. Extensive deposits of Irish Green have recently been located at Cloonacarton, near Recess, Co. Galway. The marble appears equal to the best of the Connemara productions, and, at the time of writing, arrangements are being made to place it on the market. The reports respecting the formations are of a highly favourable nature, and in the event of their being realised, it will be possible for the highest quality material to be obtained at about one-half the prices at present prevailing. There are also considerable deposits of black marble obtainable from County Galway.

Colonial Marbles.—With regard to marbles from British Colonies, the conditions prevailing have not, in

the majority of instances, been such as to favour their production. Canada, India, Natal, Rhodesia, Australia, etc., are all of them rich with marble deposits; but the development of this section of mineral wealth has been but slow, and, at the time of writing, Colonial marbles are not available for use in Great Britain. It is not practicable in any case to obtain worked material, and, in several instances, the transport charges alone on rough blocks would be sufficient to prevent Colonial products coming into competition with those from sources of production nearer to hand. There are possibilities ahead, however, in regard to marbles both from Canada and Australia, extensive deposits having been located within recent years in accessible districts.

Canada.—The neighbourhood of Philipsburg, Missisiquoi Co. (Ontario), produces calcareous, dolomitic, and serpentinous marbles, many of which are of attractive appearance and obtainable in large blocks. The formation is similar to that of the Green Mountains of Vermont, of which it is probably an outcrop extending over the Canadian border. Several varieties of marble are found at Bancroft, Hastings Co. (Ontario), and a bright red marble, with prominent crystalline veining, is obtained, with others, at Brome (Quebec). Transport charges are no higher than from many of our Continental sources of supply; and, given some slight encouragement, the marbles of the Dominion should be available for some of the requirements of the Mother Country. A Canadian (Ontario) sodalite was introduced in 1905, and has met with a favourable reception. The colour of the material is a brilliant blue, occasionally interspersed with thin red veins and spots. The beds lie in immediate contact with

PLATE VII.

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ALOMITE (ONTARIO, CANADA).

THE ONLY COLONIAL MARBLE IN USE IN GREAT BRITAIN.

[*To face p.* 114.

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a granite deposit, spurs of which, together with small pockets of black mica, project into the sodalite formation. As a result, the proportion of waste and difficulties encountered in working the material are largely increased, making its cost prohibitive for any but the highest class work. The name "Alomite" has been given to the material in compliment to Mr. Charles Allom (White, Allom & Co.), who first introduced it into Great Britain.

India.—Several deposits of choice marbles are known to exist within the confines of the Indian Empire, and a number of these were utilised both for building and decorative purposes in earlier periods. A concise account of work of this description is given by T. H. Holland in a recent publication issued by the Government of India. He states: "The Pathans and Mughals utilised both the Vindhyan sandstones of Central India and the beds of marble in Rajputana for building their magnificent mosques, palaces, and tombs in the cities of Northern India. It is only necessary to mention here Akbar's city of Fatehpur Sikri, where the red and mottled sandstone of the Bhanrer series was used, and the famous Taj, built mainly of white Makrana marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black calcareous shells from the Vindhyans of Chitor, malachite from Jaipur, cornelians and bloodstones from the Deccan, and trap and red jasper from the Gwalior (Bijawar) series."* While native marble is still employed to some extent, the principal supplies for India are procured from Great Britain and the Continent, and it is most

* "Sketch of the Mineral Resources of India," Calcutta, 1908.

improbable that the Indian Empire will become a contributor to British requirements of this nature.

South Africa.—An extensive deposit of white marble exists near Port Elizabeth (Natal), the material being of rather coarse crystallisation and somewhat soft in working. Rhodesia is reported to be as rich in marble as in other of her mineral resources. While the natural development of these Colonies may result in the opening up of marble deposits for local requirements, difficulties of transport are likely to effectually check any further expansion.

Australia.—The principal development that has taken place in the quarrying and working of Colonial marbles has occurred in New South Wales, where over thirty deposits of good quality marble have been located, many of which are being worked to advantage. The greater number of the marbles produced belong to the variegated class; fossiliferous and serpentinous varieties are also obtained, and the saccharoidal deposits are extensive. A distinct advantage possessed by practically all the varieties is their exceptional soundness, it being a rare occurrence for cramping or stopping to be required in their preparation for use.

White marble of compact texture and even crystallisation is obtained from Caloola, in the Rockley division, and the material has been used to a considerable extent both for constructional and decorative purposes at Sydney, Melbourne, and other important Australian centres of population; while with coloured marbles the deposits available are of sufficient extent to supply the entire British Empire, could they be placed on the market to advantage. Some of the varieties are of great beauty.

A marble quarried at Fernbrook bears some resemblance to Sarancolin Pyrenees (described by George P. Merrill as one of the handsomest of decorative materials), but is of richer appearance generally; Bathurst produces a variety equal to the best quality Rouge Jaspe; Rylstone marble is at least as good as Grand Antique Belge; and the Borenore, Fernbrook, Kempsey, Narrabri, Springhill, and Tamworth districts produce marbles of a highly decorative appearance, all of which are used with effect in the buildings of the Commonwealth. While a considerable amount of worked marble is still imported, the employment of the native quarried material is on the increase, and in process of time will doubtless oust the imported foreign-worked article.

So far as the exportation of marble to Great Britain is concerned, transport charges would absorb a considerable percentage of the cost of material *c.i.f.* British ports. This is not an insuperable matter, and the difference in the cost of transport of marble from, say, the French Pyrenees or North Africa, and Australia, would not of itself be sufficient to keep the latter out of the market. The principal difficulty lies in the fact that the demand for marble is a comparatively limited one, and that new varieties have, in the greater number of cases, to displace those already in possession of the market, and that can be obtained at comparatively short notice. It is the business of the marble merchant to satisfy his customer's requirements, and it is to be feared that unless Colonial Governments or their representatives can induce architects to employ their products, the development of any extensive trade from this or any other Colonial source will be of extremely slow growth. The

requirements of the British Empire can, so far as marble is concerned, be supplied from within its borders. The economics of business will not, however, allow of a searching for new sources of supply that, while as good, possibly better than those already to hand, involve a large expenditure of capital with but remote prospect of its return.

CHAPTER XI.

Continental Marble Working.

THE working of marble for the greater number of the purposes for which it is used is, generally speaking, a matter outside the quarry owner's concern. Where a regular demand exists for particular classes of work in a similar material—the machinery required being of small amount, and the labour called for is of the type ordinarily known as unskilled—it is possible for quarry owners to work their own products. Many quarries, too, have sawing machinery of a rude type as a part of their equipment, the proprietors being able by such means to supply dimension stone as well as rough blocks. For these purposes the wire saw, when in use for quarrying purposes, is readily adaptable.

With the possible exception of certain groups of quarries in Brittany and the French Pyrenees, the supply of sawn slabs from quarrying localities direct is confined to the Carrara district, where the accumulated experience of generations of workers has enabled this class of work to be done better and cheaper than anywhere else in the world. The exportation of sawn slabs has, however, been greatly restricted of recent years, owing to the tariffs imposed by various countries on manufactured or partly manufactured material, sawn slabs coming within the latter category. Belgian marbles are also imported into Great Britain in slab form to some extent; but the demand for these in an unworked state is but a small one, principally owing to the reason that

rough slabs are supplied at but little less cost than polished work, it being to the advantage of the Belgian manufacturer (who in this case is also the quarry owner) to work his own material. By keeping up the price he secures employment for his hands, both in quarry and workshop, and obtains either a small profit on each of the operations or a large one on the quarried material if his works are idle. The slabs being liable to fracture readily, are generally stuck together with plaster of Paris or a similar adhesive. With these exceptions, it is customary for quarry owners to produce block only (sometimes sawn or otherwise worked to approximate sizes), leaving it to the manufacturer to work it in such manner as may prove most advantageous to the purpose for which it may be required.

It may be generally stated that the working of marble for many of the uses for which it is employed is an industry in itself. One firm will specialise on clock cases and articles that can be duplicated by the gross; a second will manufacture little else than chimney-pieces; another will work table-tops by the thousand; yet another will make the production of marble tiles, etc., their leading feature. While it will be found that there are firms existing in most of the large centres of population that are able to supply the lesser local requirements, the execution of large decorative schemes is practically confined to a small number of establishments. That this is necessarily the case, owing to the conditions prevailing for the carrying out of such work, is apparent on consideration. It seldom happens that a scheme of decoration is carried out in the marbles of one particular district or even of one country, it being no uncommon matter for the products of five, six, or more different nations to be used in the decoration of

a single interior. Some of the finest marbles employed for decorative purposes are secured from countries that are entirely lacking in facilities for working their own products, or where the transport and other conditions, while being favourable for the exportation of rough blocks,

FIG. 44.

A WORKSHOP INTERIOR, LA BUSSIÈRE, BELGIUM.

are quite inadequate for the finished article. In any case, it would be highly detrimental to good workmanship for marbles forming the various portions of a decorative interior in which the marbles of several nations were used to be worked in their respective countries of origin. The difficulties of working would be multiplied with each sub-

contract entered into, and the task of assembling, fitting, and fixing the various portions of the work under a time contract may possibly be imagined, but certainly not described. Unless work can be carried out in its entirety at one place, effective supervision cannot be exercised, and the experience gained in this class of work has proved the futility of dividing up a contract, and the advisability of working it as a whole rather than in sections.

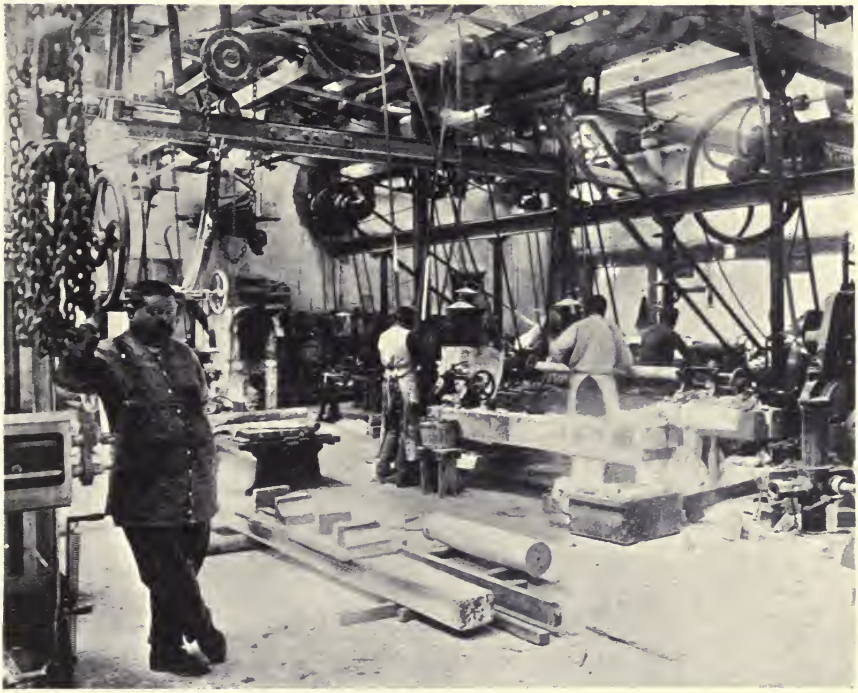
While the proprietors of the leading establishments for the working of marble are, generally speaking, themselves quarry owners, the proportion of the marbles they own is small in comparison with the bulk of their output, and the fact of such ownership is accessory rather than essential to the business proper.

One of the peculiarities of the Continental marble industry is that the principal factories for the working of coloured marbles are situated, not in any of the countries that are large producers of the material, but in Belgium, a country without natural facilities and remote from the centres of production. The industry was established at about the time of the first Revolution, possibly as a result of the unrest prevailing not only in France, but also in Central and Southern Europe; and while for many years but little advancement was made, the experience gained was of great value, and enabled Belgian houses to practically dominate the trade in the revival that took place towards the middle of the last century.* Their position

* The independence of Belgium was not proclaimed until 1836. It should be remembered, however, that, with the exception of the events of 1815, the remoteness of her position made what is now Belgian territory comparatively immune from the unsettlement that was convulsing the adjoining nations.

has often been assailed, but never successfully; and although the working of marble is now more general, Belgian establishments still occupy the premier position in this respect, and secure the best of the trade. This cannot be said to be due to any local advantages or prolific supply

FIG. 45.



INTERIOR OF MACHINE SHOP, LA BUSSIÈRE, BELGIUM.

of material close at hand. Belgian marbles are not of the highest class, and are only used for purposes of decoration where price and not beauty is the principal consideration. The leading factories, too, are situated in places well removed from the seaboard, and the finished work has consequently to bear the cost of transport of the material in both directions from the most accessible port.

Systematic organisation, based on accumulated experience, has enabled one house in particular to maintain an unequalled position in connection with this industry; and it is generally admitted throughout the trade that work placed with La Société Anonyme de Merbes-le-Chateau will be effectively carried out, and that as good value will be given as the circumstances governing the work will allow. The establishment named has four factories in Belgium, two in Germany (the larger one erected and equipped in anticipation of the tariff scheme adopted in March of 1905), one in France, and a depôt in Italy, besides agencies in leading European centres. The principal factory for the supply of work for Great Britain is situate at La Bussière, in the Soir et Sambre Valley, and there are few of our important cities that do not contain work that was fashioned in the shops of this village. The works of MM. De Jaiffe Frères at Mazy also turn out good work, and supply the British market to no inconsiderable extent.

The principal French establishments, while not being of equal capacity to the leading Belgian houses, are yet of considerable importance. One firm alone, L'Exploitation des Marbres de l'Ouest, has sawing machinery taking up to 840 blades in their factory at Quemont, and this is exceeded at their works at Sable (Brittany). Other houses that may be mentioned as possessing considerable facilities for the carrying out of decorative marble work are La Grande Marbrerie, Bagnerre de Bigorre (Hautes Pyrénées); Henri Vienne, of Cousolre, and Devillers et Cie, Marpent (Nord); and M. Cantini, of Marseilles.

Generally speaking, the French establishments are considered slightly less reliable than are the Belgian.

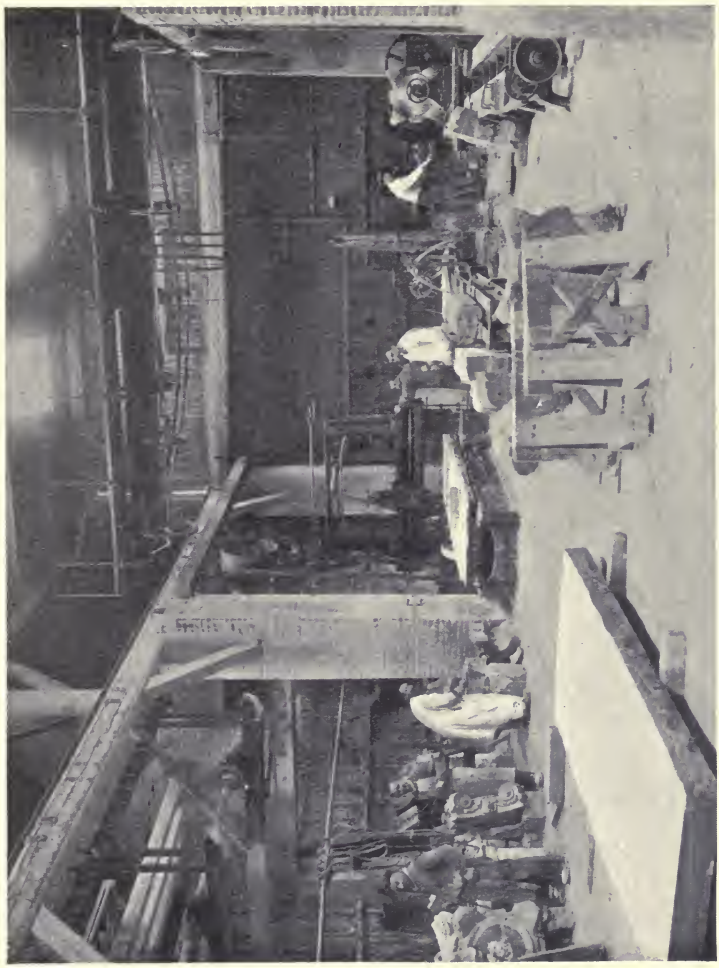


Fig. 45a.

Interior of Machine Shop, Cousolre, France.

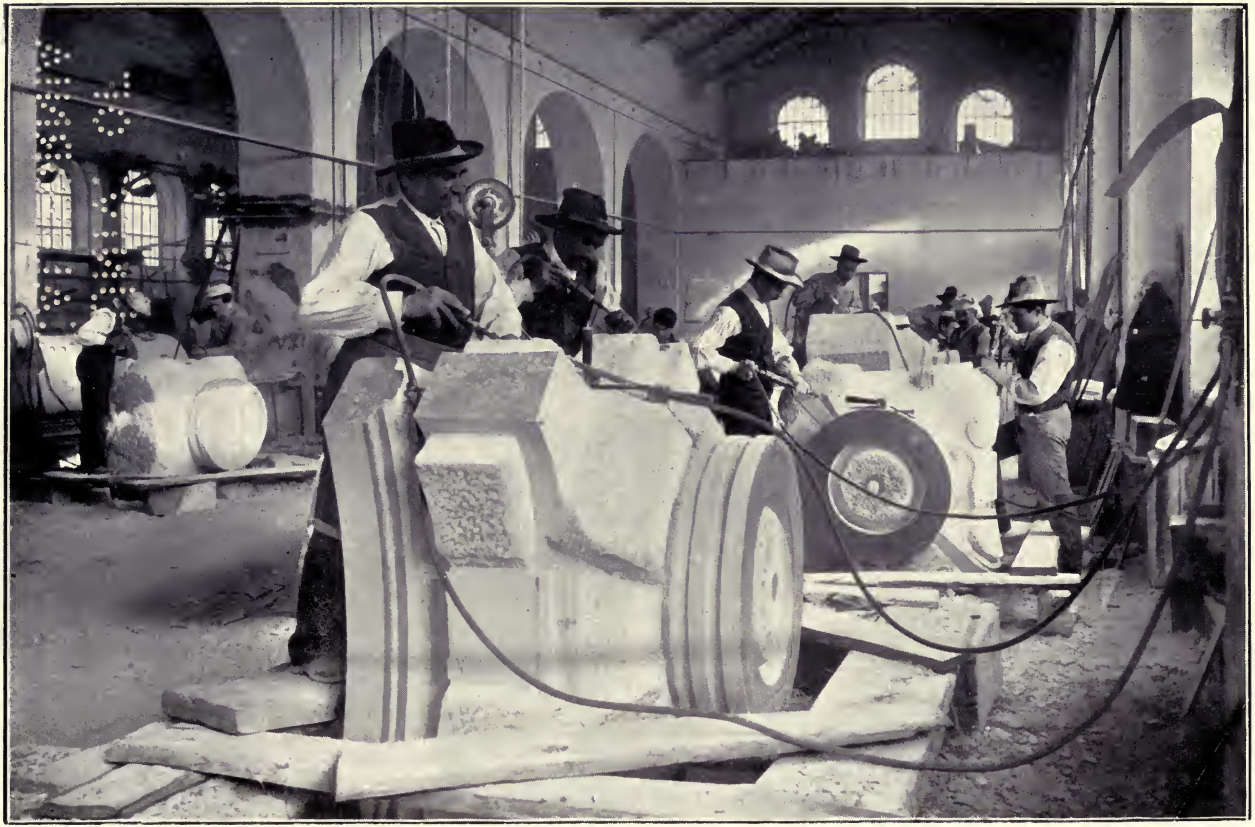
While the work is of high class, the artistic feeling displayed being exceedingly good, the former are said to be better at promising than at performing, and delays are often encountered which might with better management be avoided. These are defects that are common to many of the foreign establishments, and, while most vexatious, are likely to be experienced so long as the industry is mainly an alien one.

Marble working in Italy is, so far as decorative schemes are concerned, in an undeveloped condition. The workers are chiefly occupied with monumental and artistic work, and are not readily adaptable to other kinds. The methods of working in the Carrara district are carried out more on "rule of thumb" lines than with systematic accuracy, and the various workshops (*studii*) being under separate control, there is a lack of general supervision, arrangements for assembling the work previous to exportation being seldom made. A considerable amount of alteration and fitting is therefore necessary on the arrival of the work at its destination. Machinery is not employed to any great extent, and while a general tendency is apparent to lay down plant for working on modern lines, considerations of the first cost of installations and of their subsequent maintenance have induced Italian workers to adopt a conservative attitude in this respect. This is aptly summarised by Signor Ernesto Oraglio, of the Italian Royal Corps of Mines. Writing in 1906 on "Marble Working in the Apuan Alps,"* after describing the methods in force and the progress being made in the industry, he states: "The Apuan workshops are ruled by an artistic

* "Rassegna Mineraria," Jan. 6th and 11th 1906.

UNIV. OF
CALIFORNIA

FIG. 46.



[To face p. 127.

INTERIOR OF ONE OF MESSRS. CRIPPS' STUDII AT CARRARA.
Working marble with pneumatic appliances.

rather than an industrial principle. This prevents economical improvements from the adoption of machinery."

Certain of the Carrara studios are engaged almost entirely in the working of marble for building purposes, and in these pneumatic tools, both for dressed and moulded work, as well as for carved ornamentation, are in extensive use (see Fig. 46). The masonry for the Queen Victoria Memorial, facing Buckingham Palace, was thus worked, and a number of building schemes for leading European and South American centres have been carried through of recent years. In cases where it has been possible for work of this nature to be wrought throughout under a single management, the results have been satisfactory. In other instances, however, considerations of time, or lack of facilities to undertake large contracts, have necessitated the dividing up of the work, and some amount of confusion has consequently occurred.

Abrasive machinery of modern type is used to a small extent at Pietrasanta and Seravezza, also at Mazzano (Brescia), the last-named locality having well-equipped shops for the production of both building and decorative work in local marbles. Their productions have been in considerable use in Great Britain during the past few years, one of the latest instances being the entrance and grand staircase of the new Public Offices, Westminster, S.W. The marble is not suited for building purposes in London (see p. 57). Generally speaking, however, the efforts that have been made in Italy for the supply of the higher qualities of work for the British market have not been altogether a success, the necessary experience required in assembling and fitting the respec-

tive portions of the work having been lacking. Even where schemes have been carried out in one marble, great difficulty has prevailed in the fixing, consequent upon the inaccuracy that has obtained both in setting out and working to correct sizes; and while these are defects that will probably disappear with the gaining of experience, Italian manufacturers cannot yet be regarded as serious competitors for the better class of decorative work.

Marble working for export is also carried on at Norrköping and at Copenhagen, but the amount of worked material coming therefrom is not of large extent. This is mainly on account of the fact that local marbles only are worked in Sweden, while the Copenhagen works are practically confined to the working of Norwegian marbles.

The effective carrying out of decorative schemes in marble calls for the utmost accuracy in planning, setting out, and working. Unless this has been properly undertaken, the fixer's task is greatly increased. Every credit is due to Continental houses for the care that is exercised in fashioning, assembling, and marking the various portions of the work. Key plans are forwarded with each consignment, every piece of marble being separately numbered and its position shown. The packing of the work is, speaking generally, well done, and the amount of breakages, taking into consideration the nature of the material, low. When it is remembered that the marble work is executed several hundreds of miles from the building of which it is to form a part, that all instructions respecting such working have to be transmitted in what to the worker is a foreign language, and that consignments have to be handled at least five times between the factory and the building, the

wonder is that errors in working are so infrequent and that breakages are so small. The Continental manufacturer is to be commended for the manner in which the work is executed and forwarded.

While considerable changes have taken place of recent years in the working of the material, it may be stated generally, so far as Continental houses are concerned, that the increase in the demand for marble for decorative purposes has been about equal to that of the markets which have been lost, and hence that neither France nor Belgium have appreciably suffered from the changes that have occurred in their areas of supply.

CHAPTER XII.

Marble Working Machinery (British and Continental).

MARBLE is supplied to the manufacturer in block, and has first to be cut into slabs. For this purpose a gang saw is used. This consists of a number of blades of mild steel set in a frame at distances apart to correspond with the thickness of the slabs required, and tightly strained by wedges at the ends. In the later types of saw, the frame is suspended by short rods carried on shafts which are attached to uprights, the latter acting as guides to the frame. A connecting-rod is attached to one end of the frame, the other end of the rod being fixed to a crank connected with the shafting or with a small electric motor. This communicates an oscillating movement to the frame, and sand and water being applied, blocks placed underneath the saws are cut into slabs as required. In some cases the sand is thrown on by an attendant; in others a "shaking box" is fitted above the saw, the sand and water being supplied automatically. A type of saw in considerable use on the Continent has a centrifugal pump attached, the sand and water being used over and over again. The frames are automatically lowered by a worm and screw attachment connected with the shafts carrying the suspending rods. Fine sharp sand is the cutting medium most extensively used, but a preference is shown at times for other abrasives, such as crushed steel shot, corundum, diamond grit, etc.

Frame saws are constructed to carry any number up to 80 blades, the rate of cutting with the larger number being from $\frac{1}{2}$ in. to 1 in. per hour, using sharp

Fig. 47.

A Well-known Type of Frame Saw.
Note the short arms on which the frame swings, securing rapidity of cutting.

sand. Much depends on the cutting power of the medium employed and on the nature of the marble to be sawn. With the harder grits, while a more speedy rate of cutting

is often attained, the surface left from the saw is less even, entailing a greater amount of labour in subsequent operations. The saw-plates, too, wear away more quickly, and, all things considered, little is gained by quick-cutting mediums.

The cutting of slabs to sizes required is ordinarily accomplished by what is known as a "rip" saw, having from one to six blades, according to the work to be done. The slabs are placed in position under the saw, and fixed by plaster of Paris. The rip saw is somewhat similar to the frame saw, but is lighter in build and generally faster in working.

A method of cutting slabs to size that is in considerable use is that of the diamond saw. This is a fixed circular saw, with a number of diamonds set in its periphery. The slabs to be sawn are clamped on to a travelling table, which carries them under the saw. This method is more rapid in action, and leaves a cleaner arris than does rip sawing. It is claimed to be much more economical than the older methods. The experience of some workers has been, however, that the economy effected in sawing is sometimes discounted by the additional labour required on the rubbing bed in order to remove the curf marks left by the saw. The diamond saw is also used for cutting out scantlings for moulded work. It is capable of cutting ordinary Sicilian marble at the rate of 2 ft. super. of sawing per minute, *i.e.*, 4 ft. run of marble 6 in. thick. This does not include placing and removing the material.

Certain of the unicoloured and saccharoidal marbles are so homogeneous in structure as to permit of slabs being coped to size. This is accomplished by giving a succession of blows with a hammer and chisel along a previously

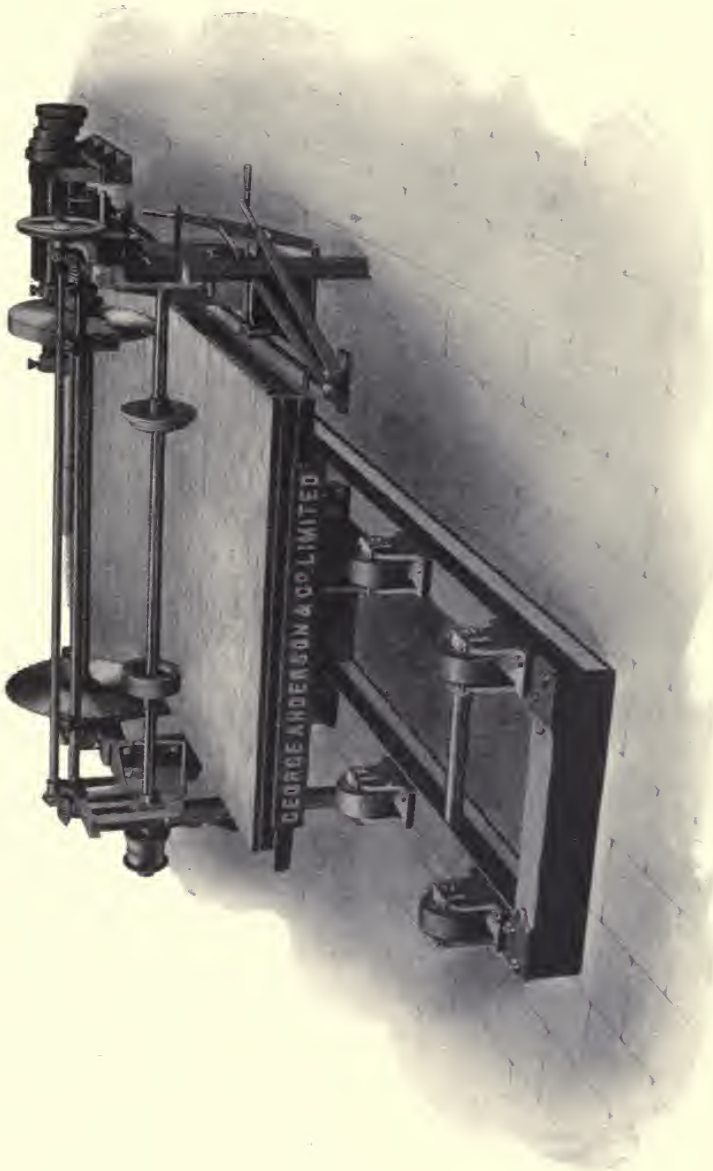


Fig. 48.

The Diamond Saw fitted with Abrasive Wheels for Moulded Work.

marked line ; the effect being to stun the marble at the point of contact, enabling it to be broken off with a comparatively clean edge. Slabs up to 2 in. in thickness can thus be secured to sizes required without difficulty, but with practically all coloured marbles sawing must be the means adopted.

The machinery used in the working of marble is of a varied character. For plain faced work, the material having been cut to approximate size, the edges are squared on a "rubbing bed." This consists of a horizontal bed of cast iron, geared to shafting on the under side and revolving at high speed. Sand and water are thrown on the bed, and the marble held in position, the abrasive action thus set up speedily giving a true edge to the marble. The rubbing bed is also used for surfacing small slabs and scantlings.

For large flat surfaces a combined rotary sanding and polishing machine is used. This consists of an octagonal frame, faced on the under side with flat iron knobs for sanding purposes, or covered with rope or felt for polishing purposes. A shaft extends from the frame, carrying a pulley on its extremity. This is connected by belting to a pulley of similar size, which connects by gearing with the main driving shaft (see Fig. 49). An eccentric rotary motion is thus given to the sanding or polishing frame. The slabs of marble to be surfaced, having been cut to size and the edges squared, are placed on a level bed, the face to be polished downwards. The backs of the slabs are then coated with plaster, and a 3-in. board, the size of the bed covered by the frame in its revolutions, placed on the plaster and allowed to set. The board is then turned over and placed under the machine,

Fig. 49.

The Rotary Sanding and Polishing Machines, Hayes.

and the rubbing frame being attached to the shafting, and the necessary abrasives applied, a true surface is speedily secured. The greatest economy in the use of rotaries is effected by keeping three or more machines running, one for each process required. The beds being interchangeable, they can be removed from the sanding to the polishing machine without delay, otherwise the work has to be washed off and the frames changed for each operation.

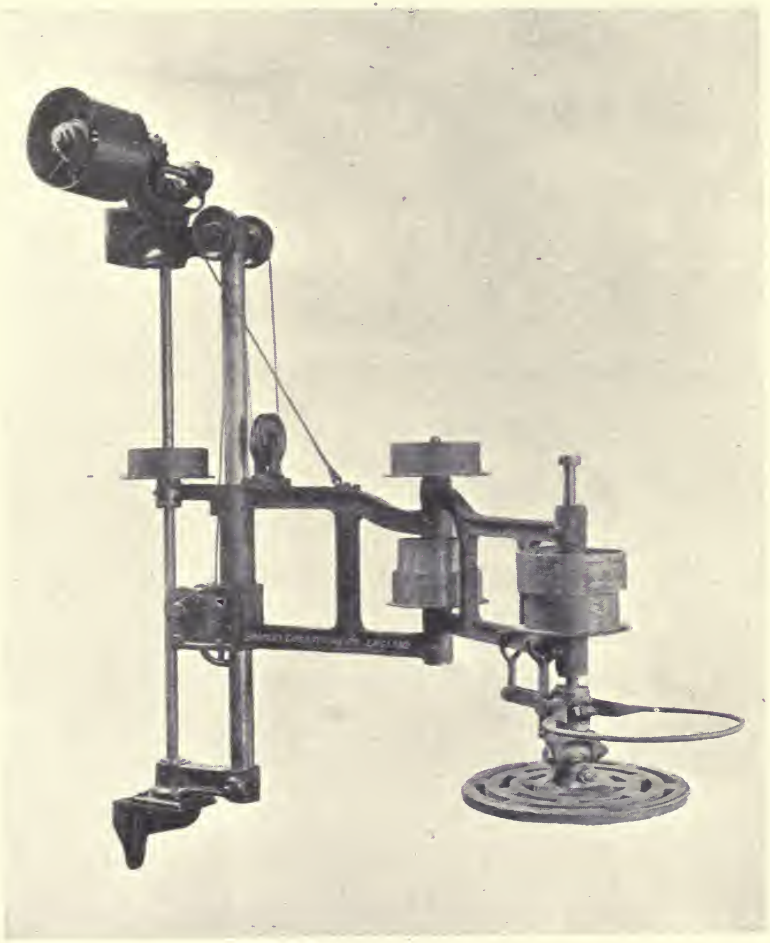
Slabs that are too heavy to be worked under the rotary machines are sometimes polished in what is known as a "blocking machine." This consists of a heavy block covered with felt, connected by a shaft to an iron frame, to which a rocking motion is given by means of a crank action. The slab is placed under the machine, and the usual polishing mediums applied as the felt-covered block travels backwards and forwards.

Another appliance used for facing work is known as a "spinner." This consists of a flat-iron perforated disc, connected to the shafting by a universal joint. The disc being placed on the marble and set in motion, sand and water are thrown on the top, and, passing through the perforations, give an even surface in a short time. The spinner is principally used for surfacing slabs that are too heavy to be worked on the rotary machines, and for giving an even face to the soffits of arched work. For the latter work a smaller disc has to be used. A similar acting disc faced with felt is sometimes used for polishing purposes.

A machine used for surfacing and polishing large slabs is known as the "Jenny Lind." This machine is constructed so as to allow the rubbing disc to be operated on

a horizontal plane in any direction desired, the rotary motion being communicated to the disc by means of

FIG. 50.

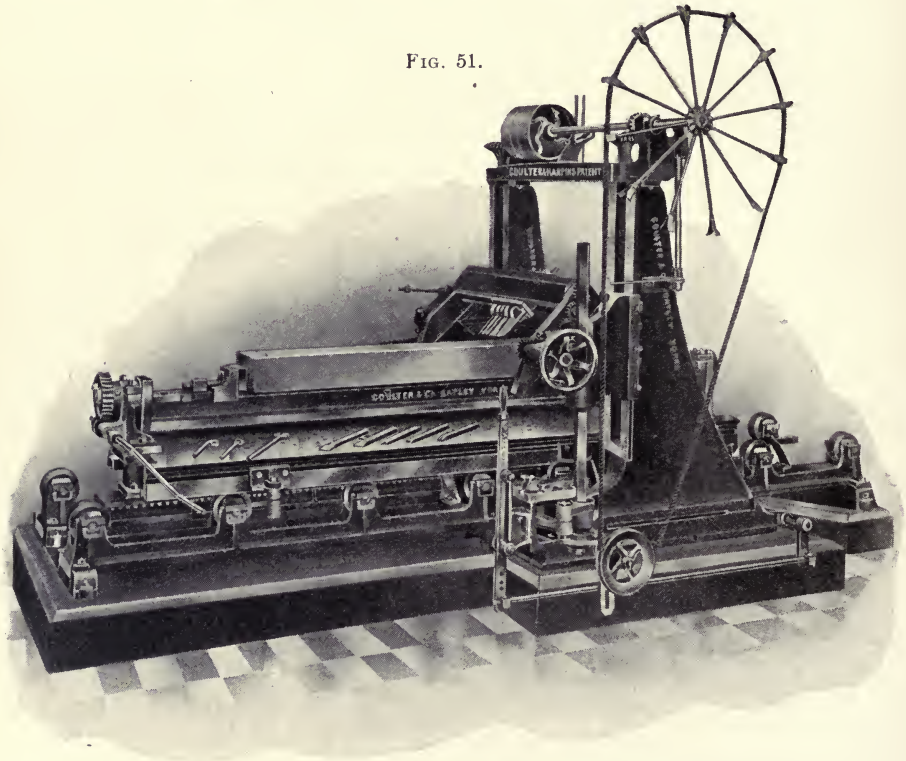


THE "JENNY LIND."
A useful machine for general purposes.

belting running over two sets of pulleys (see Fig. 50). Both the spinner and "Jenny Lind," as well as the rotary machines, work on slabs fixed in position, the area

covered by the latter being 64 superficial ft. at a single operation. Where exceptionally long slabs have to be dealt with, they are fixed by plaster to a travelling table, which runs backwards and forwards under the rubbing discs, the surface of the marble being carefully

FIG. 51.



THE "STEAM MASON."

A well-known marble moulding machine.

washed off after each operation before the final one of polishing.

Mouldings are run almost entirely by machinery. The machines used are of two distinct types, the one removing the surplus marble by a "scraping" action, the other by

the use of abrasives. The first-named are heavy machines, tools to the reverse section of the moulding to be worked being fastened in a massive box running the width of the machine. The marble, being secured by bolts and screws to a travelling table, is conveyed under the tool, and gradually worked to the desired contour. The speeding of the machine is limited by its weakest factor, *i.e.*, the cutting power of the tool. This type of machine was introduced in 1887,* and was a great advance on the hand labour formerly prevailing. Machines of similar construction are still in use in many of the Continental centres, and, in some instances, are stated to produce more accurate results than are obtained by the use of abrasive wheels.

The introduction of high-cutting abrasives for marble working only dates from 1903, but the efficiency of this method of working has been demonstrated to such an extent that in many instances the older type of machine has been entirely superseded. The medium in most general use is known as "carborundum," † and wheels of this substance, shaped to the desired section, are affixed

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* The first machine for working mouldings in marble was supplied to Messrs. Galbraith & Winton, of Glasgow, by Coulter & Co., of Batley, for the Glasgow Municipal Buildings. It is a tribute to the excellence of British manufacture that the machine is in operation at the time of writing, and is doing good service.

† **Carborundum.**—This material is the sharpest and hardest abrasive known. It is an artificial composition, produced by the fusion of coke, sand, sawdust, and salt in an electrical furnace at a temperature approximating 7,500° Fahr., this heat being maintained for thirty-six hours. The resultant composition is a crystalline mass of carbon and silicon, which is ground, graded, mixed with a binding material, and moulded to the shape desired. The abrasive efficiency of carborundum is from three to five times that of emery, and as the crystals break, they invariably leave a new, sharp edge of exceptional

to a spindle, which is caused to revolve at a speed of from 1,000 to 2,500 revolutions per minute.*

Carborundum is employed in the working of mouldings, sawing marble to size, and, in some instances, for surfacing slabs and scantlings. The material is made up either on a flat steel disc, for sawing purposes, or with a vitreous bond and soft metal bushings, for moulded work. It is also obtainable in grits of various degrees of fineness, but is much too sharp for use as a polishing medium. For sawing, it has in some instances displaced the diamond saw.

Several types of machines have been introduced for the working of marble by means of abrasives. One of the most ingenious is the Universal Stone-working Machine, produced by Bercher & Gerhäusen, of Altengronau, Hesse. This machine is so constructed that the working shaft can be adjusted to operate either in a vertical or horizontal position, or canted to any desired angle, the marble to be worked being fixed by dogs to a travelling table, which conveys the work under the wheels. The range of working admits of runs of moulding up to 6 m. in length being worked on material with a maximum width of 2 m. and depth of 1·3 m. (say 20 ft. by 6 ft. 6 in. by 4 ft. 4 in.). An attachment is also provided for turning balusters and small ornaments, and the working of mouldings for shaped and circular work. Some idea

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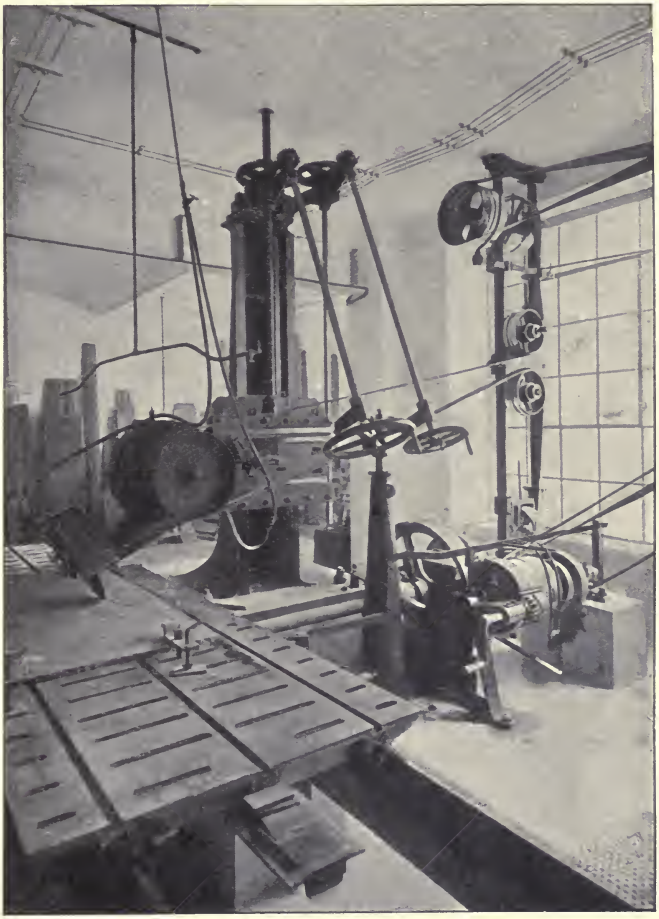
hardness; the material is also some 28 per cent. lighter in weight than emery, bulk for bulk. The latter feature is of great importance when the high speeds at which the wheels are run are taken into consideration, the breaking strain being in every case proportional to the weight of the substance used.

* The workable speed of carborundum wheels may be taken as averaging 5,000 ft. of periphery of wheel per minute.

of the work that can be done by the Universal Machine can be obtained from the sections of mouldings illustrated (see Figs. 52 and 52A). For lengths of 1 m. (say 40 in.),

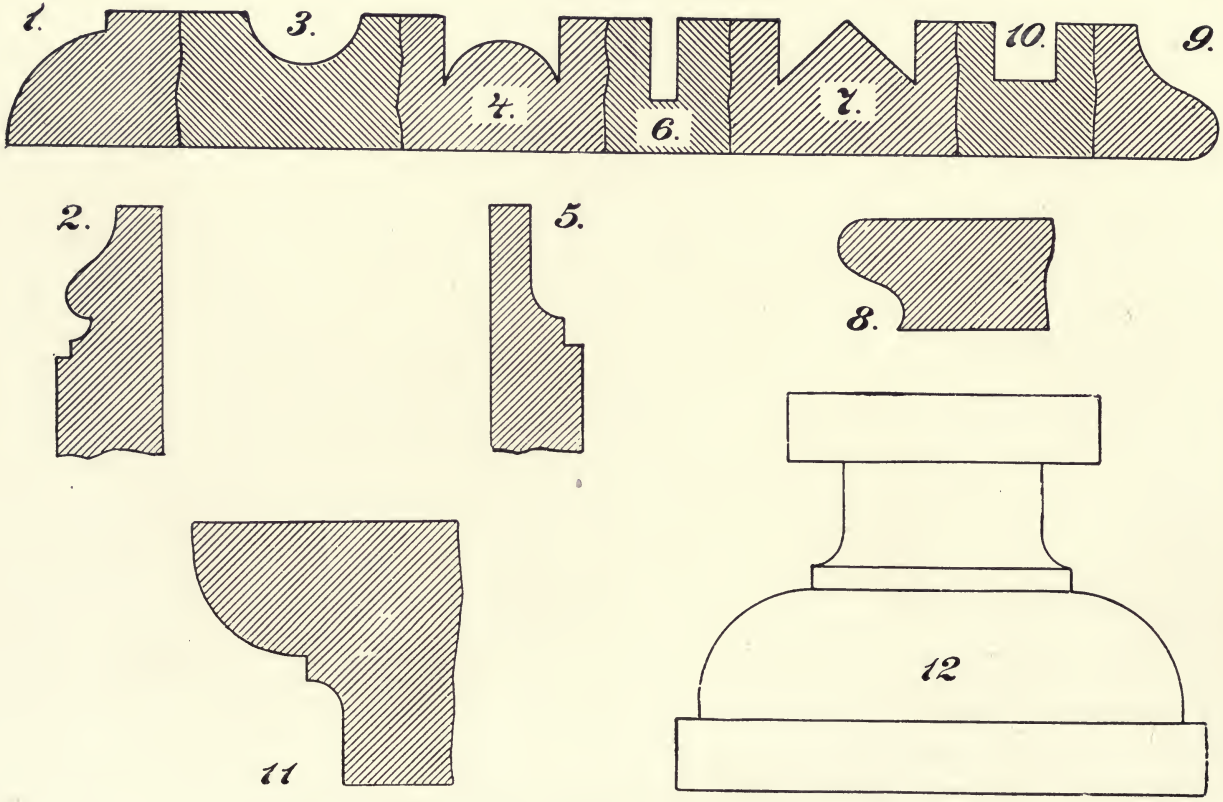
FIG. 52.



THE UNIVERSAL STONE-WORKING MACHINE.

all from sawn marble slabs, sections 6 and 10 are run in three and a half minutes each; sections 3 and 4 in five minutes; section 9 in eleven minutes; sections 2,

FIG. 52A.



SECTIONS OF WORK DONE BY THE UNIVERSAL STONE-WORKING MACHINE.

5, 7, and 8 in fifteen minutes; and section 11 in twenty-five minutes, when worked from a square edge, and twelve minutes when the edge had first been sawn (also by the machine) to an angle of 45°. The turned baluster shown in section 12, worked from marble that had been roughly bevelled, was completed in six minutes.* The sections are drawn one-half full size.

The advantages secured by the use of abrasive wheels over machinery of the older type are very considerable. The machines required are less heavy and simpler in design; the cutting wheels can be adapted for working either vertically or horizontally; an entire section of moulding can be completed in a single operation; and, perhaps the more important feature of all, the surface of the work as it comes from the machine is smooth and almost ready for the polisher to work upon. The medium used for the composition of the wheels wears to such slight extent as to permit of their use for long periods, provided they do not break, and the contour of the edges may be altered, if required, without great difficulty.

One of the uses for which abrasive wheels have been employed is the making of marble tiles for flooring purposes. Two hollow wheels are mounted on a spindle at a distance equal to the width of the tile required, and the machine being set running, a slab of marble of slightly larger dimensions than the finished tile is passed between the wheels. The guide can be canted to any angle for the producing of lozenge-shaped tiles or of octagons. The machine produces tiles of a uniform size

* These times do not include the fixing and removing of marble on the table.

and with a sharp, true edge, in about one-tenth of the time taken by the older methods.

Pneumatic appliances are used to some extent both for moulded and carved work. The plant consists of a compressor from which air at a pressure of from 50 lb.

Fig. 53.

Masons Working with Pneumatic Tools, Hueyapam, Mexico.

to 80 lb. to the square inch is conveyed through flexible tubes to the hammer. This consists of a valve and piston arrangement, giving a striking action of over 3,000 blows per minute, the tool being inserted against the piston. The force of the stroke is easily adjustable by the workman.

The lathes required for marble working occupy an important place in the manufacturer's equipment. It is no uncommon thing for monolith columns to be called for weighing 7 tons each or over. A lathe capable of supporting this weight on centres must necessarily be of a heavy type. The marble for columns is generally quarried separately, and roughed out to within $\frac{1}{2}$ in. or 1 in. of their finished diameter by hand. Steel centres are then inserted in the ends, and the embryo column fixed in the lathe. The work of turning is done by free-revolving cutters made with a bevel edge out of specially hardened steel. These automatically travel along the side of the rough column, cutting into and removing the surplus material as the lathe revolves (see Fig. 54). Carborundum wheels, working by means of flexible shafting, are sometimes used in this connection. The final processes are effected in a polishing lathe by means of cast-iron weights, gritstone, emery, putty powder, etc.

The casing of iron or steel pillars with marble columns involves a considerable amount of labour. The columns, having been turned and polished, are sawn through the centre, care being taken to prevent any chipping at the edges on the bottom of the cut. To avoid this, the columns are bedded in plaster of Paris. The halves are then hollowed out either by hand or by means of the diamond or abrasive saw, which, on being suitably adjusted, puts in a series of cuts that are afterwards broached out by hand. Sufficient material having been removed to give clearance to the girder or pillar to be cased, the edges of the half-columns are rubbed together so as to show a fine joint, and are then ready for fixing. The jointing is so accurately done that it seldom happens that repolishing is necessary.

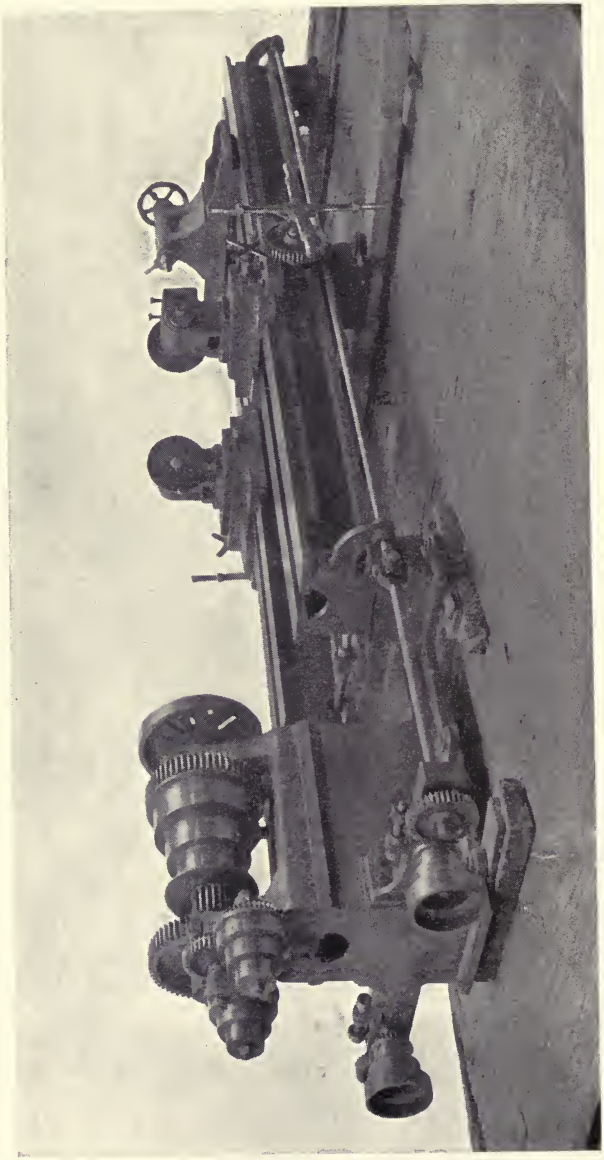


FIG. 54.

DOUBLE-ACTION LATHE FOR TURNING MARBLE.

The carving of marble is generally undertaken by a separate staff. Respecting this class of work, machinery is of little use, the whole work being a matter of artistic feeling and training. Machines have been in use for some years past for repetition work, but the general experience has been that no advantage has been gained by their use. One of the types that has been introduced is known as the "Wenzel" machine. The principle of the machine is as follows: A number of revolving drills and a fixed point are set in a balanced frame in such manner that the point and drills occupy the same relative position. A block of marble having been placed under each drill and fixed in position, and the model to be copied secured under the fixed point, the machine is set in motion, and the point passed over every part of the model, the theory being that each of the drills will thus scoop out a replica of the model. The main difficulty encountered is, that in undercutting, the drills are not sufficiently sensitive, and on too much pressure being applied, the marble breaks away. This defect may be overcome in time, in which case the machine will be of great use for repetition work. Even then the work would have to be finished by hand. A machine working on a similar principle has been installed and abandoned in Italian workshops, but this might be due as much to the cheapness of labour in Italy as to any defect in the machine. Machine carving has been shown to be of utility for the reproduction of statuettes and other small articles, but so far as the carving of marble for decorative purposes is concerned, its success has yet to be demonstrated.

No machine has yet been devised for successfully

polishing moulded or carved marble work. Various chemicals have been tried with the object of securing a quick and lasting polish, but in no case have these been attended with success. In this field, at any rate, labour is able to hold its own. A good polish can only be secured by vigorous rubbing with various polishing mediums. The selection of the materials to be used for securing a lasting polish depends to some extent on the nature of the marble to be operated on. For marbles that "close" readily, putty powder (oxide of tin) and rouge are generally sufficient; but where "pins" are encountered, and with marbles of such nature that the surface presents different degrees of hardness, it is necessary to use various materials in order to secure a good polish. These include emery powder, either used separately or mixed with lead filings, corundum, tripoli, and putty powder. Water is used in a decreasing amount with each process. In many of the Continental centres polishing is mainly carried out by women and girls, and the standard of efficiency is high.

The slabs used for wall linings are ordinarily supplied worked to a nominal thickness of $\frac{3}{4}$ in. A system has, however, been introduced of late by leading Continental houses of sawing marble to produce a $\frac{3}{8}$-in. slab, and cementing these, after they have been cut to the sizes required, on to a backing of low-priced marble or other suitable material of similar thickness, the composite slabs being then sanded and polished on the rotary machines in the usual course. The material most in use for backing is known to the trade as Belgian or Petit Granit. This is a carboniferous limestone, somewhat similar in formation and appearance to dark Hopton-Wood stone, and is obtainable in large sizes and at comparatively small cost.

Where a panelled design to include bands of different coloured marbles is called for, this method makes for economy both in working and fixing. It also admits of finer jointing being obtained than would be the case were each slab to be fixed separately, while for the more expensive marbles the reduction effected in the substitution of a backing—the first cost of which is less than 2*s*. per foot cube, for material costing 16*s*. or over—is appreciable even after the cost of the additional sawing and cementing is taken into consideration.

The system, however, cannot be recommended for the best class of work. While the utmost care may be exercised in cementing the backing to the faced marble, the slabs are apt to spring the one from the other, and, once this happens, a thoroughly satisfactory job cannot be secured. Alterations that may be necessary in work after it arrives on the building, too, are most difficult to carry out in the backed material, and in fixing the work it is necessary to insert the cramps and dowels that are used between the backing and the faced marble, when, if settlement afterwards occurs in the building, every cramp becomes a small lever with a tendency to force the slabs apart. The faced work is also liable to work loose from the backing if the building is subjected to any considerable amount of vibration. In any case a stringent guarantee should be required from the firm supplying such material to replace any slabs that may become defective as a result of the loosening of the backing.

Some of the coloured marbles are liable to contain flaws or vents, and when these are apparent, either in slabs or moulded work, cramps are inserted on the under side of the material to prevent development. Where a backing

is used for slab work, cramping is generally considered unnecessary. The surface of the marble has, wherever necessary, to be filled in with an artificial medium. This is generally a part of the polisher's work. A perfect medium for filling cranks and vents in marble has yet to be found. It should be capable of being coloured to the desired shade, impervious after application to heat or moisture, and of a nature to take and retain a polish equal to that of the marble. Most polishers make up their own preparations, the principal ingredients being gum shellac mixed with colouring matter. A workman possessed of skill in this direction is seldom wanting employment even in Belgium, where the "stopping" of marble is exceptionally well done.

The types of machinery described in the present chapter are in general use both in Great Britain and on the Continent, and it is worthy of note in this connection that the machines used are mainly of British manufacture. In fact, it may be stated that British machinery for marble working can be found in all parts of the world, and that the shrewdness of the purchasers has been justified by the results obtained. In the more recent developments that have taken place in Germany and Great Britain, it has been possible to make greater use of the more recent appliances, there being no accumulation of machinery of older type.

CHAPTER XIII.

Marble Working in the United States—American Machinery Described and Compared.

THE greatest development that has taken place in the marble industry has occurred in the United States of America. Mention has already been made of the progress that has taken place both in quarrying and quarrying appliances (see Chapter III., p. 41, etc.). When it is remembered that the output of American quarries during the past decade has increased thirty-fold, that the imports of marble in block have not diminished, and that the exports have been practically *nil*, it will readily be perceived that the growth of the marble-working industry has been phenomenal. Another point of interest is that while the importation of marble in block continues, the employment of worked or partly worked material, other than antique work, has declined to a considerable extent.

This is due to the policy inaugurated by the late President McKinley, of placing a tariff on material competing with national productions, varying in amount with the proportion of labour that had been expended on its preparation.* The result has not only been to give

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* The present tariff on marble imported into the United States is as follows:—

Marble of all kinds (block, rough, or squared), per cubic foot .	$0.65
Onyx in block	1.50
Slabs or paving tiles of marble containing not less than 4 superficial in., up to 1 in. thick, per super. foot . . .	0.12
Slabs or paving tiles of marble containing not less than 4 superficial in., up to 1½ in. thick, per super. foot . . .	0.15

a considerable impetus to the quarrying industry, but also to give special encouragement to the working both of American and imported marbles in the country.

At the time of the introduction of the tariff the quarrying trade was a fluctuating one, subject to local difficulties as great, if not greater, than those prevailing in the British industry. The entire production of the Green Mountains of Vermont, the most prolific of the American marble fields, was then valued at less than £30,000. To-day one concern alone operating in this district has an annual turnover approaching three-quarters of a million sterling, and employs over 3,000 workmen. Then the working of marble, apart from building and monumental purposes, could hardly be said to exist. Several of the principal decorative schemes in leading cities were carried through by the New York branch of a prominent London firm (Burke & Co.), who obtained the greater part of their marble, worked ready for fixing, from an equally prominent Belgian house, the fixing alone finding employment for local labour.

Marble is used in the United States for building purposes to a very large extent; but the decorative trade is now a large and increasing one, and, since the tariff came into force, but few instances of imported worked marble, other than works of antiquity, are on

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Slabs or paving tiles of marble containing not less than 4 superficial in., up to 2 in. thick, per super. foot . . .	$0.18
(If rubbed in whole or part, 3 cents per super. foot additional.)	
Mosaic cubes of marble, onyx, or stone, not exceeding 2-in. cube in size, if loose, per pound . .	$0.01 and 20 per cent.
If attached to paper or other material, per super. foot . .	$0.20
Manufactures of onyx, alabaster, etc., n.e.s. . . .	50 per cent.
Works of art for public exhibition or public monuments . .	Free

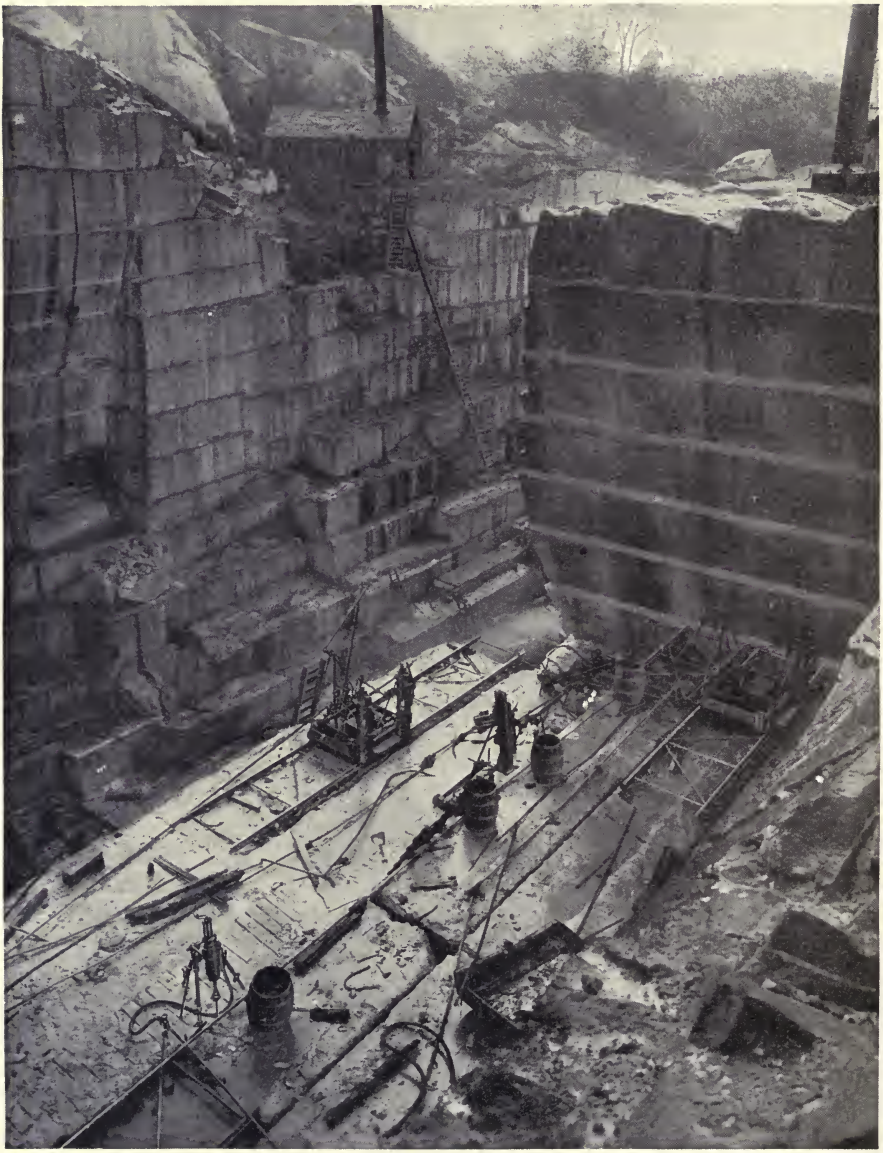
record. That the immense development which has taken place in all branches of the industry is a direct result of the legislative policy that has been adopted is beyond

FIG. 55.

ARCHITECTURAL CARVING EXECUTED WITH INGERSOLL PNEUMATIC APPLIANCES, NEW YORK, U.S.A.

question. It encourages the quarrying of native material, and ensures that what has to be imported comes in, so far as possible, in an unworked state, thus securing

FIG. 56.



A SOUTH DOVER (U.S.A.) MARBLE QUARRY IN WORKING ORDER.
Opening up a new floor.

employment for American work-people rather than those of another country. The demand for labour being high, its remuneration rises accordingly, and the American marble worker, whether employed in mine or quarry, factory, or fixing on a building, receives higher wages and works under better conditions than his compeers in any other part of the world. At the same time his employer keeps the trade and makes a good profit, the increased prosperity of the country enabling higher prices to be secured, the quality and finish of the work being at the same time improved. Such is the American's justification of a tariff on marble. Whatever may be said for or against the protective theory, it must be admitted that, so far as the marble industry of the United States is concerned, the adoption of a tariff has been more than borne out by results.

The employment of abrasives for the working of marble is more highly developed in the United States than elsewhere. Carborundum* is the medium in general use, and although the great cutting power of this substance, as applied to marble, was first recognised by Offenbach, of Germany, Blanpain & Jaspart, of Paris, and Anderson, of Carnoustie, Scotland, it has been left for J. Royden Pierce, of New York, to apply it to the industry generally, and to utilise its wonderful properties to their fullest extent.

The entire carborundum process, as applied in leading American factories, may be briefly described. The quarrying methods in force permit of blocks being secured to sizes required, and these are converted into slabs by ordinary gang saws. The slabs, as they come from the

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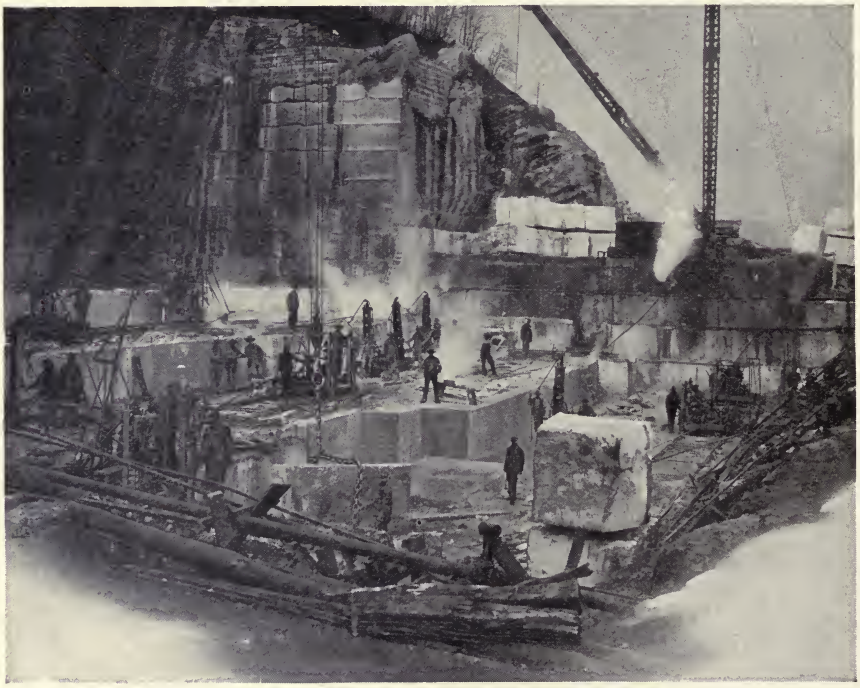
* See Chapter XII., p. 139.

saw, are run face downwards through the "drum rubber." This consists of a massive steel shaft upon which is slipped a carborundum sleeve, the slabs passing between the drum, which is revolving at high speed, and an iron cylinder known as the "idler," the latter being covered with a

FIG. 57.



QUARRYING BLOCKS TO SIZE, KENNESAW, GEORGIA, U.S.A.

Note the undercutting of the quarry wall on the left of the picture, and Sullivan Gadders at work splitting up the channelled layers.

thick coating of rubber. The machine will work slabs up to 12 ft. in length and 6 ft. 6 in. in width, and the idler can be adjusted to work material up to 12 in. in thickness. The rubbed slabs (the veining and colour of which are distinctly shown) are then stored in the yard. Here they

are selected, matched, and the sizes to which they are to be cut marked out by an operative known as a "marker." The marked slabs are taken from their places in the

Fig. 58.

Matched Panel of Dark Creole Marble, Georgia, U.S.A.

bins by special grappling hooks, and placed under one of the copers. (All the machines must be under travelling cranes.) If the work required is to be in strips, it goes to the *Gang Coper*, the strips being afterwards cut to correct

length on the *Cut-off Coper*. Panels or scantlings for mouldings are treated on the *Turning-head Coper*.*

In all cases pieces are cut to exact size, leaving perfect arrises requiring no subsequent treatment. The pieces are next conveyed to the polishing machines. These are equipped with special polishing rings, composed of suitable abrasives, which become finer in grit as the finishing progresses. Narrow bands and strips are polished by the automatic base-feed polishing machine. The two-wheel moulder, counter-sinking machine, and lathe, as their names indicate, do work of a familiar class requiring no description. They are of similar working principle to those already described, save that the lathe has two cutting heads, carrying carborundum wheels on horizontal spindles, and two fluting heads carried on vertical spindles. Electrical power is employed throughout, each machine and, in the case of the lathe, each head being operated by a separate motor.

A peculiarity shown in marble worked by the carborundum process is the surface finish obtained, whether in slabs or mouldings. The first operation consisting of a regular abrasive action, in which all particles are removed in one direction, the surface retains an indication of the process throughout, and while a hard semi-polish is secured, the action of reflected light gives what may best be described as a "silky sheen." This may be varied in surface work by having contiguous slabs rubbed in opposite directions, making the woven effect vertical in one piece and horizontal in the next. This effect is known as the "spine finish," and can, of course, be varied as desired.

* A "Coper" may be described as a carborundum circular saw, the names given to the respective machines indicating their use.

Fig. 59.

The Carborundum Process: Works Interior at Ravenswood, Long Island, New York. (W. Bradley and Sons.)

Reputed to be the largest and best-equipped Marble Works in the world.

[*To face p.* 158.

The whole of the machines are of an exceedingly heavy type, this being necessary in consequence of the vibration otherwise set up, consequent on the high speed at which carborundum wheels have to be run in order to obtain the best results. The drum rubber weighs 20 tons, and will surface from 800 to 1,200 ft. super. of marble per day of eight hours, the amount depending on the kind of marble, size of slab, and quality of sawing. It requires 65 h.p. to operate it, and has a water consumption of 100 gallons per minute. The two-wheeled moulder weighs 12 tons, and will work a moulding of 8 in. girth containing six members (out of $5\frac{1}{8}$ in. by $3\frac{1}{2}$ in. material) at the rate of 10 in. lineal per minute. It requires 35 h.p. and 30 gallons of water per minute. The lathe (taking columns up to 20 ft. in length by $3\frac{1}{2}$ ft. diameter) weighs 40 tons, and requires 20 h.p. for the operating motor, and 25 h.p. for each of the cutting head motors, or 70 h.p. in all.

While considerable advantages are secured in the working of marble by the entire carborundum process, the writer is of opinion that, under existing circumstances, no European factory could economically utilise the system in its entirety. The ratio between power and production is one of the more important of the questions with which the marble manufacturer has to deal, and it is to be feared that the power required to operate the entire plant puts it outside the range of practical working—at any rate, in the leading establishments of Europe. The economic efficiency of machinery is dependent upon its being kept in regular employment, and as the output of even the largest works does not approach the capabilities of the drum rubber

alone, the trade would have both to concentrate its working and develop to a very large extent before the introduction of the process is practicable. Besides, the entire equipment is a most expensive one, and would necessitate the discarding of existing machinery; and so long as the importation of American worked marble into British and Continental centres is not commercially possible, or until it is seriously competitive, it is unlikely that American methods of working will be introduced this side of the Atlantic.

PLATE IX.

FROSTERLEY (DURHAM) MARBLE.

[*To face p.* 161.

CHAPTER XIV.

Marble Working: A British Industry.

WHILE being of less relative importance than in Continental countries, the art of working in marble in Great Britain is an old-established one. Frosterley (Durham) and Purbeck (Dorsetshire) marbles share the distinction of being the earliest known varieties to be worked, instances of the use of each of these marbles dating back to the twelfth century. The columns of Durham Cathedral, the pavement of York Minster, and portions of the tomb of Archbishop Scrope are well-known instances of the early application of the former marble to ecclesiastical work; with the latter, the cathedrals of Winchester, Worcester, Lincoln, and Salisbury will serve as illustrations of its employment. One of the finest instances of the use of Purbeck marble may be found in the tomb of Richard Beauchamp, Earl of Warwick, in the choir of St. Mary's Church, Warwick. The cost of this is given as being for the marble, carriage to Warwick, and work, £45. Taking the high value of money in those days (beef and mutton were sold at $\frac{1}{2}d.$ per pound, veal and pork $\frac{3}{4}d.$, wheat 3*s.* 4*d.* per quarter, etc., *vide* Pollock's "History of England"), this would be equivalent to about £800 at the present time. Petworth marble was used in Westminster Abbey, also in the cathedral churches of Canterbury and Chichester. Furness marble was employed in ancient work at Holker Hall, one of the seats of the Duke of Devonshire. Anglesea

marble was mentioned by Thomas Pennant in 1733, and numerous examples exist throughout the country of the employment of British marbles both for constructional and decorative purposes.

The first instance known of the application of other than hand labour for sawing marble in the British Isles was the establishment of the Kilkenny Marble Mills, worked by water power, in 1730. These are situated on the River Nore, some two miles south of Kilkenny, and the business, though on considerably improved lines, is still in existence.

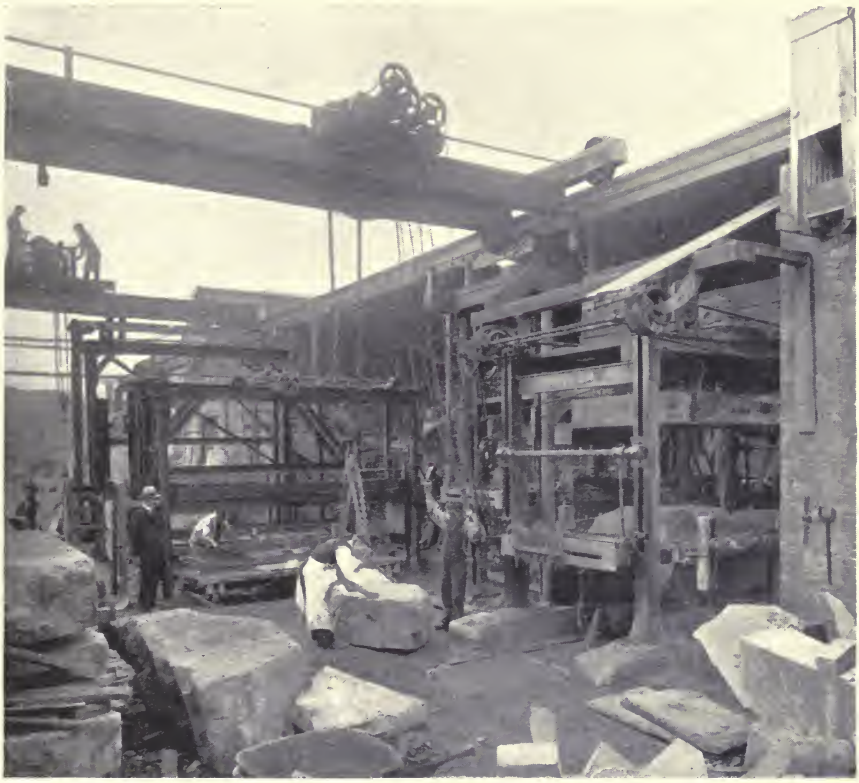
The Devonshire marbles were in extensive use for church buildings in Devonshire and Cornwall throughout the Mediæval period, but were practically unknown outside their local areas till the beginning of last century. They were employed to a small extent towards the close of the Georgian period, and might still have remained in obscurity but for the energetic efforts of the Torquay and Plymouth marble workers, who have (the former especially) persistently urged their claims for general recognition. They are now, however, worked to a considerable extent, and while the use of many of these marbles is curtailed on account of circumstances already referred to, but slight encouragement would result in their employment being largely increased.

The monumental trade is mainly an imported one, only the lettering and fixing giving employment, in the majority of instances, to home workers. Occasionally, what is known in the trade as "purpose-made" work is required, and only in such cases is the work carried out in this country. It is possible, with the extended use of Greek marble, for this to be remedied somewhat; but

failing such use, the probabilities of a revival of British working in the monumental trade are, under existing circumstances, remote.

Marble for shop-fitting is generally required at short

Fig. 60.



British Marble Working: The Saw Frames, Torquay.

notice, and, so far as this branch of the industry is concerned, British firms have a distinct advantage over Continental houses. The tendency to specialise in work of this description is apparent, and business houses who make this class of work their leading line are mostly able

to hold their own. It is noticeable that a workman engaged in this, or any higher branch of the industry, does not take kindly to the "tombstone trade," and only reverts thereto when he entirely fails to find employment in other branches of the industry.

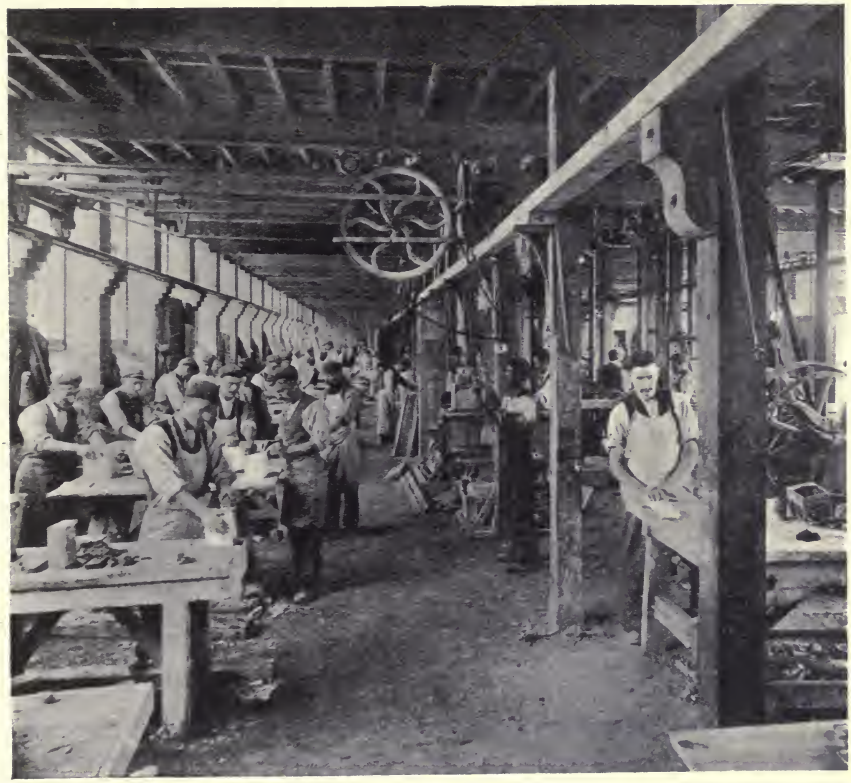
Sanitary fittings and work in the lower-priced coloured marbles are sometimes undertaken by shop-fitting firms. This, however, only happens when there is insufficient time to have the work executed abroad, and even then there is generally keen competition with houses that supply decorative marbles as their principal line.

Hospital fittings and electrical work both call for extreme accuracy, both of workmanship and fixing, and work of this description is usually undertaken by firms making a speciality of decorative work, their appliances being better suited to ensure these requirements.

The greatest amount of progress that has taken place in the marble industry of the country of late years is to be found in the working of marble for decorative purposes. In Ireland works have been erected at Galway City for the manipulation of the Connemara marbles; extensions have also been made in Dublin and Kilkenny; in Glasgow the leading firm of marble-workers have considerably enlarged their working facilities; expansions have occurred both in Derbyshire and Devonshire, while in London and the immediate neighbourhood considerable extensions have been carried out by several firms (including the building and equipment of a new factory at Camden Town), and works have been erected at Hayes, Middlesex, that are stated to be the second largest in Europe.

The worker of marble in Great Britain has several difficulties to contend with that are out of the ordinary run. He has to be either a holder of large stocks of expensive material, some of which may not be required

FIG. 61.



BRITISH MARBLE WORKING: INTERIOR OF THE MARBLE WORKS, TORQUAY.

for several years, or must keep in close touch with sources of supply extending over an increasingly wide area.

The equipment of the works is a matter of considerable expense. A travelling crane, capable of lifting from 10 to 15 tons, is an absolute necessity, and hand cranes

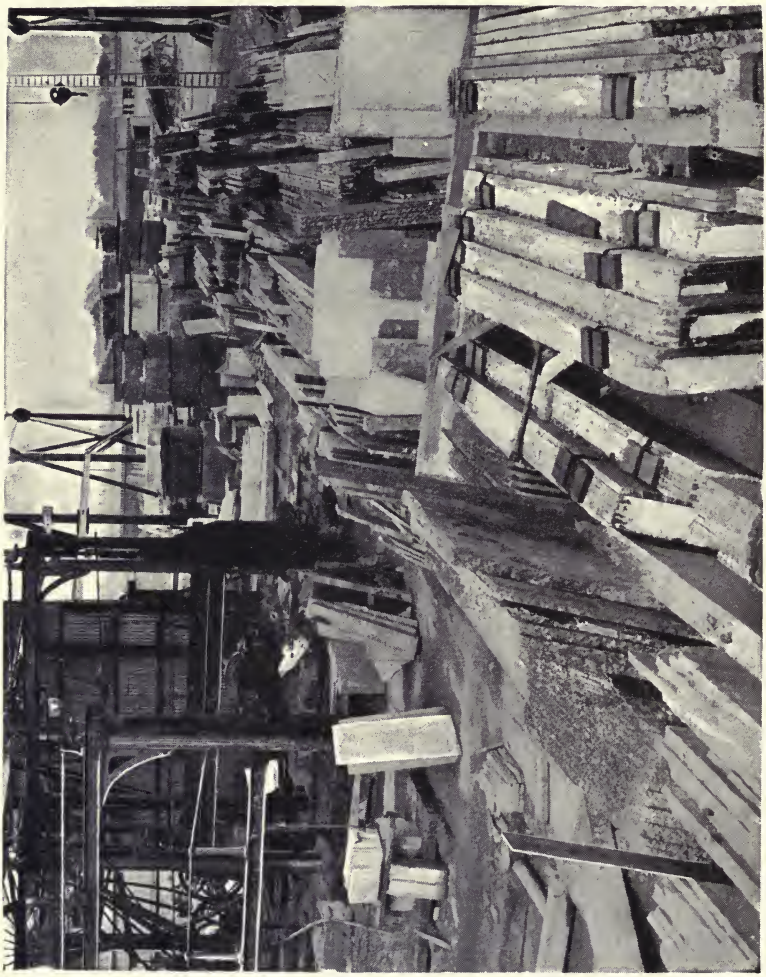


FIG. 62.

BRITISH MARBLE WORKING: THE MARBLE YARD, HAYES.

to almost as great strength must be supplied to traverse the workshops. A large amount of costly machinery, some of which will probably be idle for a considerable portion of each year, must be maintained. Estimates have to be made up several months, and in some cases years, before the work can be put in hand, and the manufacturer has to take all risks of variations in the cost of the material during the intervening period. In addition to this, he must be provided with a considerable floating capital to provide for wages and current charges on work he may secure. The greater part of the material required must be purchased, and both the material and the labour employed on its working paid for, some time before a possible payment on account can be expected. The amount of capital required in proportion to the turnover is consequently high, and the difficulties encountered in establishing the industry very considerable.

The fact that work of a high-class description can be executed in this country has been demonstrated, amongst others, by Messrs. Farmer & Brindley, of London, who have carried out several important contracts at different times, employing British labour throughout. Well-known instances are the reredos at St. Paul's Cathedral, the staircase, etc., of the National Liberal Club, the later extensions of the National Gallery, etc. The marble work at the Great Central and Great Eastern hotels of London is British worked, by far the greater part of the work being executed at Glasgow by Messrs. Galbraith & Winton, who have also carried out several important marble contracts in various parts of Great Britain, the entire work being of home manufacture. The use of British alabaster for general decorative work is extensive,

and considerable quantities of this material are worked at Uttoxeter (Staffs) and in Derby, as well as by ecclesiastical sculptors in various parts of the country. The best instance of the employment of this material is, in the writer's opinion, to be found in the interior decoration of the Guards' Chapel, Wellington Barracks, S.W. The whole of the work was executed in the shops of Messrs. Burke & Co., then of Newman Street, W. The productions of H. T. Jenkins & Sons, and W. Blackler & Sons, of Torquay (Devonshire marbles),* and the Hopton-Wood Stone Firms (Derbyshire marbles), too, are well known in architectural circles, as are several of the schemes carried out by T. Emley & Sons, of Newcastle-on-Tyne, Whitehead & Sons, The Art Pavements and Decorations, Limited, Anselm Odling & Co., Walton, Gooddy & Cripps, Greenbank & Edmondson, of London; Watts of Colchester, etc.

The principal effort that has been made in this direction, however, is that of Arthur Lee & Brothers, Limited, at Hayes, Middlesex. In 1902 this firm built and equipped an up-to-date factory for the working of large contracts, which, as far as its equipment is concerned, compares favourably with the finest establishment on the Continent (see Fig. 63). The progress that has been made, although, perhaps, not so great as the promoters of the venture desired, has not been unsatisfactory. The work that has been executed at Hayes includes the marble work for the entrance hall,

* The interior decoration of Lloyd's Registry, Fenchurch Street, E.C., is a fine illustration of the employment both of British labour and British marble. The marbles are principally from Devonshire, the work being executed by Messrs. Jenkins.

Fig. 63.

British Marble Working: Interior of Marble Works at Hayes, Middlesex.

[To face p. 168.

corridors, etc., at the new Sessions House, Old Bailey, the University College, Birmingham, the National Provincial Bank, Aberystwyth, besides several private house interiors and contracts of smaller extent situated in various parts of the country. As many of these contracts have been obtained in open competition with firms supplying Continental-worked marble, it is evident that it is possible for work of this description to be done in this country.

The advantages to be obtained by placing marble work at home rather than abroad are many. The chief of them may be briefly enumerated. (*a*) The risk of error in interpreting drawings is reduced to a minimum, it being always possible to submit a doubtful point to the designer as soon as it arises. A more correct interpretation of the scheme the architect has in view is therefore secured than would otherwise obtain. (*b*) Setting out can be done to greater advantage, the building for which the work is intended always being accessible for measurement. A wall slightly out of position can be arranged for, otherwise it may make a considerable difference in the appearance of the work when completed and fixed. (*c*) The risk of breakages is greatly reduced, and, when they occur, replacements can be effected with the smallest amount of delay. This is a matter of increasing importance in view of the high price of land and rental values in our large centres of population. (*d*) Minor alterations can, when required, be arranged for without an undue expenditure either of time or money. These, while often adding to the attractiveness of an interior, are not always practicable where Continental-worked marble is concerned. (*e*) The working can be arranged and the

delivery of consignments to the building regulated so as to keep the fixers continuously in employment, at the same time saving storage room for work not required. The convenience both of the contractor and specialist is thus studied, to the advantage of all concerned. (*f*) Effective supervision can be exercised by the architect over the material used and workmanship displayed in the execution of his design. This is not possible where the work is of foreign origin.

Perhaps the greatest advantage of all is that the architect knows with whom he is dealing. The writer has had experience of both ways of doing business, and may perhaps be allowed to point out the difficulties that are bound to exist where the firm that is executing work of this description is not brought into contact with the principal contracting party. All instructions are given at second or third hand, and explanations of delays in working (and these are not uncommon) handed on, sometimes modified and sometimes embellished, oft-times without actual knowledge as to their correctness; and while the responsibility of the work rests with the firm tendering, the fact of its execution by a third party who is outside the actual contract often results in inefficiency. On the other hand, where the contracting firm is actually doing the work, no excuse can possibly remain for inaccurate working or for avoidable delay, the parties being in touch each with the other throughout.

Fixing is in all cases carried out by local labour. The correct position of the floor levels, centres of openings, etc., are first set out on the building, and the fixing proceeded with, starting at floor level. The marble is secured to the

wall by cramping, holes being driven into the wall to receive the cramps, which are set in plaster of Paris, the joints being stopped with a mastic of similar colour to the marble. Marble facings in courses are sometimes fixed by dowels on the lower edge, securing the slab to the course below, and cramps on the upper edge, securing the slab to the wall. The material used for cramping is either copper, brass, or galvanised iron wire of $\frac{1}{4}$ in. diameter. (The use of the latter material is not recommended.) For all slab work an air space of not less than $\frac{3}{4}$ in. should be provided between the backs of the slabs and the wall of the building. Unless this is done, damp from the walls will penetrate the marble, causing efflorescence. Heavy cornices are secured in position by long cramps, the size, shape, and material of which are generally specified by the architect. Columns should be secured by dowels of not less than $\frac{1}{2}$ in. diameter, stouter sizes being requisitioned for heavy columns. These may be either of slate or of some non-corrosive metal. Iron, even if galvanised, should not be used for this purpose.

Marble work is generally coated with a wax solution before leaving the factory, so as to protect the surface from dust and scratches. This is cleaned off after the entire work is fixed.

The development that is taking place in the use of marble for building purposes calls for more than a passing mention. Early in 1907 the order was placed with Messrs. Arthur Lee & Brothers to work the material for the first erection in Pentelikon marble in this country. To-day work of an aggregate value of over £80,000 is either in hand or completed, and further erections in the material

are under consideration. Much uncertainty prevails as to how this work is to be carried out, builders, monumental and stone masons all being anxious to see what they can do in the matter. A word to the wise is sufficient. Only those knowing the nature of marble can work the material to advantage. It always has been and always will be a specialised industry, and sooner or later must revert to "the trade." In the same way as it takes an Aberdeen or Dalbeattie man to work granite to advantage, so the marble mason will ultimately hold his own, and the efforts of those outside the business to take a hold can only result in the buying of experience.

CHAPTER XV.

Marble Substitutes and Imitations.

The increase that has taken place of recent years in the use of marble has induced inventors to search for some medium that should be available for the various purposes for which the material is used, and by which a profit could be realised. Products of this nature come on the market from time to time, most of them bearing some high-sounding appellation of which the word marble forms a part. Some are called after their inventor; others are given a name calculated, in the mind of its originator, to convey some idea of the substance produced, often with no more success in this respect than their product obtains in the public estimation. It is possible that many of the substances produced may be available as decorative mediums, but it can be generally stated that none of these productions are marble, that few of them are good imitations of marble, and that in some instances it requires an effort of the imagination even to term them decorative.

Of the many attempts that have been made to produce marble artificially, but one has come within a measurable distance of success. The patented process of Mr. T. M. Thom, now being worked by the British Stone and Marble Company, Limited, has approached nearer to an actual reproduction of Nature's handiwork than has any other; and while one thoroughly familiar with the natural product would not be likely to mistake it for the

Company's article, the similarity is, in many instances, remarkable. The process may shortly be described as follows. The chemical constituents of the marble to be produced having been ascertained, *débris* of calcareous, dolomitic, or carbonaceous limestones, or substances possessing similar chemical composition, is secured, and, after analysis, is calcined; the carbon dioxide generated being collected, liquefied, and stored for use at a later stage. The residuum is then withdrawn, ground, and slaked, the various minerals present in the marble to be reproduced being added, if required, at an intermediate stage in the process, thus giving the necessary colouring matter and reproducing, as far as possible, the natural formation. The plastic material is next conveyed to an hydraulic press, and pressure is regulated so as to conform to, or be higher than that of, the natural stone. After being dried, the slabs are placed in a cylinder, a vacuum created, and the liquefied gas previously stored fed thereto. Pressure is applied as required, until the matrice becomes impregnated, forming a carbonate of equal or higher specific gravity than the natural marble, and of identical chemical composition. Microscopical examination shows the structure of the reconstructed product to be crystalline throughout.

It is claimed for Mr. Thom's process that stone can be reproduced that is harder and more reliable than the natural production, and that cannot be distinguished by ordinary means from the original article, and so far as chemical, physical, and microscopical tests are concerned, the claim is borne out. Several of the unicoloured and carbonaceous marbles are reproduced with marked similarity, and with certain of the variegated kinds a

close resemblance is discernible. The crystalline structure of the re-made stone is apparent on fracture, and the surface being polished by similar methods, it presents a like appearance to that of natural marble. Some difficulty is experienced, however, in reproducing the crystalline veining which gives to many of the variegated marbles their distinctive appearance, and the process is not quite successful either with the saccharoidal or laminated varieties, while the fossiliferous, brecciated, and serpentinous varieties, as well as the travertines, have up to the present defied imitation.

The process enables any desired tint to be given to the material, and its wearing qualities are guaranteed to be at least equal to Nature's productions.

Reconstructed Sicilian marble was selected for lining the walls of the operating-rooms at the Manchester Royal Infirmary, opened last year.

One of the Company's productions (reconstructed Portland stone) was used in 1906 for the erection of premises at 13, City Road, E.C. The specific gravity of this stone is given as 2·59 against 2·145 of natural Portland stone, and the crushing strain is much higher than that of natural stone. Microscopical examination shows that the special characteristics of the original stone are present in the re-made article, and that the perfection of the cohesion throughout the mass is due to the uniformity of the crystallisation of the calcium carbonate in the matrix in all parts of the block. The stone has given satisfaction both to the architect and contractor using it. At the time of writing, its resistance to atmospheric action has been equal to the patentee's claim, but the future alone can settle its correctness.

FIG. 64.

No. 13, CITY ROAD, LONDON, E.C.

The first building to be erected in Reconstructed Portland Stone.

Reconstructed Ketton stone has also been used in the Cheshunt Free Library, the material being practically indistinguishable from the natural production.

One of the most extensively used marble substitutes is known as "Scagliola" Marble. This is a material in considerable use for decorative schemes in cases where time will not permit of marble being supplied. It is capable of being prepared and fixed so as to present an unbroken surface, allowing for the casing of iron or steel stanchions, pillars, etc., without showing a joint. This is at times of distinct advantage. The process is Florentine in origin, has been extensively employed throughout Europe since its revival in Italy in the early part of the sixteenth century, and has been in use in Great Britain since the middle of the eighteenth century. Scagliola is entirely a decorative medium. Its base is plaster of Paris, the colouring matter being added and the face hardened by secret processes, the application of which is carefully guarded. The material is principally used for the interior decoration of theatres, hotels, public buildings, etc., and was at one time in extensive use for private house interiors. While the surface is less even than that of marble, it presents a pleasing appearance, is without flaws, does not require stopping, and takes a good but not brilliant polish. The cost of Scagliola is rather higher than that of low-priced decorative marbles, but many architects prefer using it to the latter for comparatively inexpensive work. While its appearance bears no comparison with the richer varieties of coloured marbles, the gain of time secured by its use over that required for the preparation and fixing of the latter causes it to be in considerable demand for good class work.

Venetian and Roman mosaic have been in occasional use for many years past as dado panelling, the upper part being decorated in the usual manner. The application of marble chippings for entire surfaces of walls is, however, of recent date. The material in use is known as "Patent Wall Marble Mosaic," and consists of Sicilian marble chippings mixed with Portland cement and vegetable colouring matter, the brickwork being covered with the mixture while it is in a plastic state to a depth of $\frac{3}{4}$ in. (Steelwork, etc., is first covered with expanded metal or other suitable material.) This is well worked in, and a final material of similar nature, the marble chippings being of a rather larger size, plastered on the top and screeded off to a level face. The surface is afterwards rubbed down with grit-stones of various fineness until a dull polish is obtained. An instance of the employment of the material in London is the wall linings to lavatories at Victoria (S.E. & C.) Railway Station, S.W. For dadoes, etc., a combination of assorted marble chippings of various sizes are cemented together, so as to present a veined, brecciated, or wavy appearance. The substance was first used in 1906 for the interior of the Liverpool Cotton Exchange, and is in considerable demand. It looks well, and while being an efficient substitute for marble for certain purposes, is not, and does not profess to be, a marble imitation.

An opal glass wall tile of ordinary brick size, the surface having a reproduction of various marbles, obtained by a photographic process, and afterwards burnt in, is sometimes used. The writer has observed several instances where this medium has been employed for wall facing (exterior and interior). It is supplied in various shades,

but the whole of the reproductions are of identical markings! Brown and Green St. Anne's are certainly not Nature's productions, and the combination of colour and marking, to put it mildly, presents a strange appearance to anyone who is familiar with the real article. Where the natural colour is used, a sample tile, viewed from the face, bears a remarkable resemblance to the marble that is copied; but viewed *in situ* the repetition of the same patterns in 9 in. by 3 in. close-jointed tiles becomes monotonous. What it is like when presented in a colour altogether foreign to the marble the reader may imagine, or, by exercising his faculties of observation, may see for himself. The material appears to be brittle, and the edges of the tiles become chipped with the smallest amount of rough usage, presenting a most unsightly appearance. It is, however, seriously recommended as a substitute for, and of similar appearance to, marble for shop fronts, lobbies, stall boards, etc., and is so used.

The material sold under the name of "Manu-Marble" is in considerable demand both for floors and for purposes of decoration. It is claimed for this product that the chemical composition is similar to that of marble, with none of the flaws and vents prevalent in the real article, and that the colours go right through; also that the material has all the natural and artistic properties of real marble. This, in the writer's opinion, is hardly correct. The principal chemical constituent ($CaCO_3$) is common to such widely differing substances as mountain limestone, several varieties of marble, and chalk; and in this respect the claim advanced is correct. But while the material is micro-crystalline in structure, its specific gravity is slightly lower than that of marble; it is of

less hardness, and, when tested by immersion in water, absorbs from five to eight per cent. of its weight. With regard to its claims from an artistic standpoint, the entrance hall and staircase of the new St. James's Hall, Great Portland Street, W., is lined with Manu-Marble, and readers desirous of satisfying themselves on the point may compare this with genuine marble decorative work. (In this instance the staircase balustrade and pedestal cappings are executed in St. Anne's Marble, the body of the pedestals and the lower string course, as well as the door architraves, being in Manu-Marble of somewhat similar colour tone and marking.) The material appears sound in structure, the colours are permanent, and the cost is little over that of glazed tiles. It is suited for use in cases where lowness of cost has to be the main consideration, and where what may be described as a "marble effect" is sought to be obtained without the expense of securing the genuine material.

A material of recent introduction is described as "Fassio" Marble. This is frankly a marble imitation. It does not claim to be equal to marble, or of similar chemical composition, or of having any claim other than that of a decorative medium giving a "marble effect," and available for use where marble cannot be employed on account of its cost. The groundwork of the material is a non-flammable substance, of similar nature to fibrous plaster, but with a prepared face impregnated with a representation of the colouring and markings of the marble desired, and treated with a secret process which hardens the face, the slabs being polished in the ordinary manner. The thickness of the finished slabs does not exceed $\frac{3}{16}$ in., and they can be cut and fitted with a stout

pocket-knife. The material is available either for new work or for renovations ; its appearance is not unattractive, the colouring is permanent, and the polish is of high grade. It will not, however, stand rough usage, and is best employed in conjunction with a dado of greater resistance to hard knocks than obtains with the " marble " itself. For this purpose slabs are supplied to a thickness of $\frac{3}{4}$ in. The material is low in price—is, in fact, the most inexpensive decorative medium of its kind on the market, and, where suitably employed, is of considerable utility. It presents a good appearance, and while not being or pretending to be marble, is, for purposes where lowness of cost is the principal consideration, an efficient substitute.

Generally speaking, while certain of the productions sold as marble imitations or substitutes have an attractive appearance, and are suitable for use in approved positions, it is a straining of terms to call them " marble " or even to class them with the material. They are only applicable for employment in place of the real article in cases where considerations of time and cost are prevalent, and can hardly be utilised for good class work. Their principal recommendation for favourable consideration is, in the majority of cases, that they are cheap. The writer is impelled to observe that, in the greater number of instances that have come under his observation—they look it !

CHAPTER XVI.

Practical Points for Architects' Consideration—Hints on the Selection of Marble.

THE majority of schemes of marble decoration are carried out on competitive lines, and in many cases specifications are either entirely absent or are so vaguely worded as hardly to be regarded. It is to be feared that this policy does not result in the best either of material or workmanship being secured. Severe competition, especially in the marble trade, often results in the Continent being ransacked for low-priced material, and rigid economy being exercised in the labour that is engaged in its working. When it is remembered that not only the architect, but in many instances the contractor supplying the work, sees and knows nothing respecting the quality of the material that is being supplied until after the arrival of the various consignments, and that, in the event of this differing from the samples submitted, the defence of natural variations in the material can always be set up, it is not surprising to find that in many cases work does not come up to one's expectations. Under the circumstances it is only possible to supply average quality material, or something inferior thereto. To quote for material of the best grade, costing 10 or 20 per cent. additional to that your competitors may offer, is not a policy that commends itself to the business man, but one that if adopted would soon land him in the Bankruptcy Court. The consideration that must obtain

is not what best can be supplied so much as what it is possible to get passed.

Architects are themselves largely to blame for this state of affairs. They have in several instances allowed the trade to hint to them what they should or should not use; to suggest that this would be less expensive, that that would be quicker supplied, and that the other would be more effective; all the time echoing the wishes and desires of their Continental allies. Attention has seldom been paid to the suitability of particular marbles to the purposes for which their use was projected, while the soundness or otherwise of the respective varieties has been referred to, if at all, in the most casual manner. These methods have not made for efficiency.

The marble merchant, too, is not without blame. It is not a rare thing to see at the heading of a quotation for marble work a printed statement implying that all coloured marbles are unsound, and are only supplied subject to the firm quoting being allowed to cramp, stop, or otherwise treat the material. This may have been less incorrect twenty years ago than it is to-day. Quarrying methods have improved since then, and new varieties, many of them of sound structure, have come into use. The writer has no hesitation in declaring that a statement of this nature, while amply covering the supply of inferior material, is a libel on marble. It is a fact that a large proportion of the coloured marbles in use in Great Britain can be supplied free from flaws, vents, or faults that necessitate cramping either previous to or during working; and while the number requiring stopping on the face is considerable, there are several varieties in which this treatment is unnecessary, save in

very exceptional cases. If it were made a condition of contract for marble work that no material which had been broken in working should be used, and that stopping (save in the case of marbles named in the specification) should not be resorted to for other than filling a vein, there would be less shellac used in the works, and the supply of defective cramped marble would be greatly diminished. The quality of the material supplied would thus be considerably improved, and that without any appreciable increase in the price at which good class work could be obtained.

The matter remains in the hands of the architect. It is he who decides as to the conditions on which the work is placed, and, in the majority of cases, he is the sole arbitrator as to the efficiency or otherwise of the material supplied. If he be content to place his work in the cheapest market and on the contractor's conditions, he must not be surprised at receiving as little as he may be induced to take. If, on the other hand, he makes reasonable conditions, and insists on their fulfilment, the quality of the work will be vastly improved, and he will obtain the gratitude and support of the better class manufacturers. It is not to the interest of good class firms either to supply low-grade material or to employ poorly-paid labour. The conditions prevailing in the trade force them, directly or indirectly, to do both, and until a definite stand is taken in the matter, it will neither be possible for the best to be secured nor reasonable for it to be expected.

Hints on Selection.—The selection of marbles for decorative schemes that are projected is often a matter of considerable difficulty. It is almost impossible to

obtain a correct impression respecting the appearance a marble will present when fixed on the walls of a building by viewing a small sample piece, and large sample slabs are both expensive to secure and difficult to handle. Where a "new" marble—*i.e.*, one not previously in ordinary use—is sought to be introduced, the supply of large sample slabs showing, as far as possible, the extreme variation of colour and marking in the bulk of the material should be required, and information should be sought for respecting the suitability of the material for the purpose for which it is required, the place where it is to be worked, and the stocks in hand and available for the execution of the contract. With marbles in ordinary use, such precautions, while to some extent advisable, may not be imperative. It is often possible in the latter case for an architect himself to inspect buildings where similar marbles to those he contemplates using have been employed, and after taking into consideration the varying effects of light and shade, and, where necessary, the altered effect produced under artificial light, arrive at a conclusion respecting the suitability of the marbles inspected for the purpose he has in view.

In all cases it is advisable to reserve the right of examination and, if necessary, the rejection of the material at any stage of its manipulation, and to make provision for such examination by the architect or building owner or their representative at any period during its working. It must not be forgotten that the circumstances attending the later stages of the erection of a building are often of such nature that time is of even greater importance than the efficiency of the material used for decorative effect; that the replacement of faulty material is, so far

as marble is concerned, a lengthy business; and that after a building is occupied, it is of great inconvenience to those in possession for alterations and replacements to be proceeding. It is to be feared that when a building is close on completion (and where delay in opening means a heavy loss in prospective rent earned, besides outgoings that have to be paid), much is allowed to pass which would have been rejected if supplied during the earlier stages of the work, or if the material had been inspected before being put in hand or early in its manipulation.

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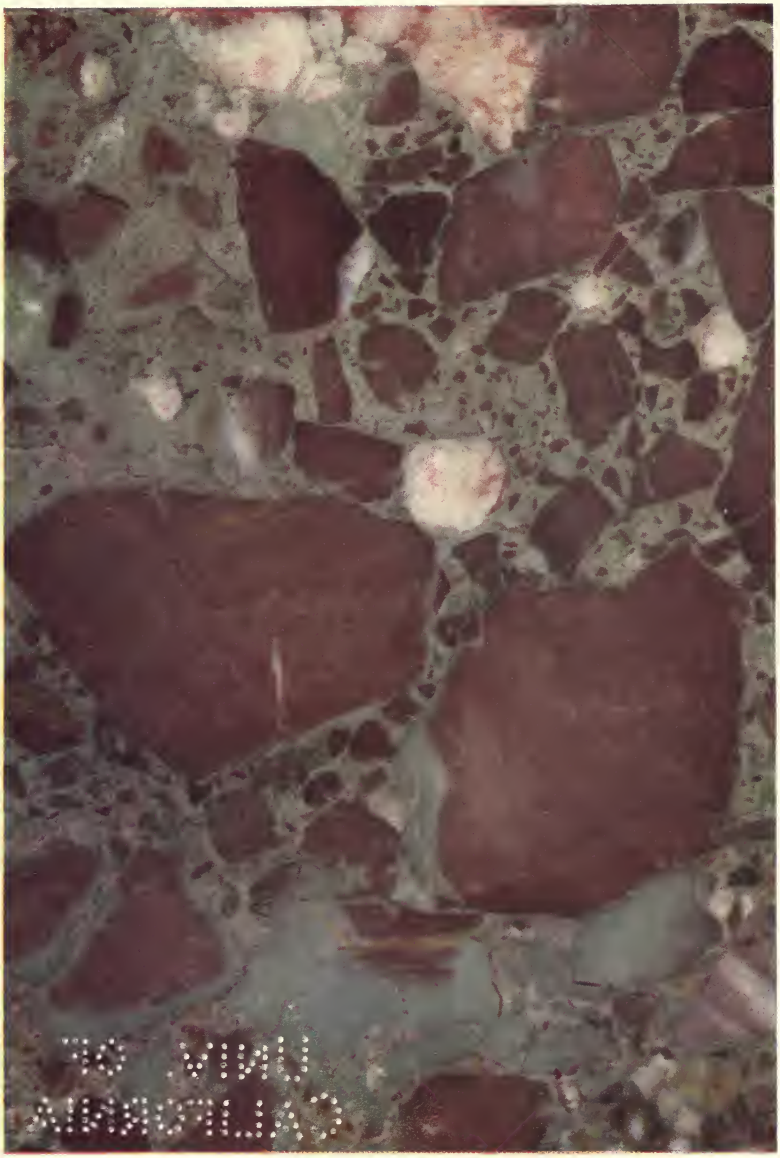
PLATE X.



AGRELLEI (CALABRIA, ITALY).

[*To face p.* 187.

SUPPLEMENTARY.

List of Marbles in Ordinary Use, with Descriptive Notes and Instances of their Application.

The list of marbles presented herewith comprises the leading varieties in use in Great Britain and Ireland. It is within the writer's experience that most, if not all, of the marbles used in the provinces are also to be found in London buildings; further, that more is known generally respecting the Metropolis than of any provincial centre, and this has led to his confining the illustrations given of places where marbles have been employed to London buildings. The instances quoted are selected not because they are the best that could be adduced, but mainly for the reason that they are accessible without difficulty, and, in the majority of cases, without even the formality of obtaining permission to view. So far as possible, buildings situated on main thoroughfares are taken for similar reasons. The student of British marbles should not fail to visit the Geological Museum in Jermyn Street, Piccadilly; while an afternoon spent in the Roman Catholic Cathedral, Victoria Street, S.W., will enable him to realise something of the dignity and grandeur that can be expressed in this medium when controlled by a master hand. A description of the marbles used is given in the Guide to the Cathedral, on sale at the entrance.

Agrellei.—An Italian brecciated marble of recent introduction, the prevailing colour tone being a brownish red, with white crystalline patches. Quarried in Calabria. Sound, and of rich appearance (see Plate X.).

Alabaster.—Sulphate of gypsum. Used for similar purposes to marble, and generally supplied through marble masons. The British (Staffordshire and Derbyshire) varieties are in most extensive use. Cream ground, with reddish brown veinings and markings. Soft, and presenting a waxy appearance when polished. Prominent instances of its use are wall-lining to grand staircase, Holborn Restaurant, W.C.; interior of British Linen Bank, Threadneedle Street, E.C.; the Guards' Chapel, S.W., etc. Used for exteriors: Columns and pediment to entrances at Broad Street Place, E.C.

Alomite.—Also known as **Princess Blue** (from the interest taken by H.R.H. the Princess of Wales in the introduction of the material into Great Britain). A Canadian sodalite, deep blue in colour, with small red specks. Only suitable for inlays and small ornaments. Used as inlays to pilasters in Upper Hall, United Kingdom Provident Institution, Strand, W.C., etc. This material appears much darker in hue under artificial light (see Plate VII.).

Algerian Onyx.—*See* **Onyx.**

Arizona Onyx.—*See* **Onyx.**

Arni Alto.—An Italian variegated marble, having a white ground and veinings ranging from light green to deep purple, the markings in the latter case being at times very heavy. Also known as Vert Bella and Arni Vein. Opens up well for panels. Sound. First used at Debenham's, Wigmore Street, W.C., in 1907, and has rapidly come into favour. Used for wall-panelling at the entrance to Dewar's offices, Haymarket, S.W. (see Fig. 65).

Fig. 65.

A Study in White and Green: Arni Alto, Campan Vert, and Tinos.

Ashburton.—One of the best-known varieties of British (Devonshire) marbles. Fossiliferous. Dark grey, merging on black, with bright red and white crystalline veins. Sound, and obtainable in large sizes. Used for skirtings, etc., at Lloyd's Registry, Fenchurch Street, E.C., etc. For exterior work, the restaurant entrance at Victoria (S.E. & C.) Railway Station can be quoted.

Bardilla or Bardiglio.—An Italian variegated marble, having a light blue ground with fine pencil veinings of deep purple. Quarried at Carrara, Massa, and Seravezza. Hard, close texture, very brittle. A variety in which the veinings are irregular, presenting the appearance of flowered markings, is sometimes called Bardiglio Fiorito. The names are identical at the quarries. Used as dado capping, architraves, etc., in entrance hall, Hotel Victoria, S.W., dado panelling to marble hall lounge, Grand Hotel, W.C., etc.

Bay Vein.—One of the varieties of Devonshire (Plymouth) marbles. Medium-toned red, with grey patches and white crystalline veins. Not in extensive use.

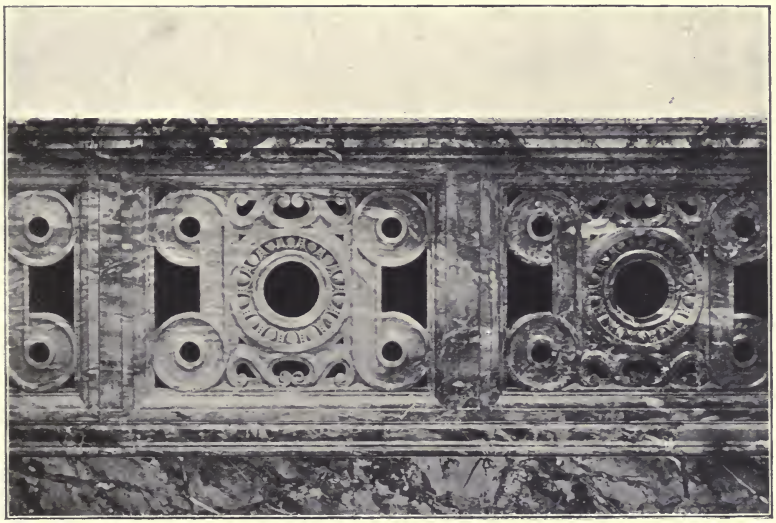
Belgian Granit.—A Belgian carboniferous limestone of dark grey colour, having small white fossils thickly distributed through the formation. Quarried extensively in the Province of Hainaut and the Hoyoux and Ourthe valleys (Liège). Sound, obtainable in large sizes, and takes a medium polish. Principally supplied to Great Britain for low-price washstand tops, sanitary work, etc., also as a thin backing for more expensive marbles. Used for building purposes in ground floor of 29, Minories, E.C., London and County Bank, Camberwell Green, S.E., etc.

Birdseye.—A British fossiliferous marble. Dark grey to brown ground, with light grey crinoidal fragments.

Quarried at Wirksworth (Derbyshire). Sound, and obtainable in large blocks. Used for skirtings and caps and bases of large columns in entrance hall of new Sessions House, E.C., etc.

Black Marble is obtained from Belgium, France, England, and Ireland. Derbyshire Black is very fine in grain, and takes a good polish. Irish (Galway) black is

FIG. 66.



A MARBLE DADO: STAIRCASE AT HOTEL RUSSELL.

Pierced Panels of Siena Marble, with Belgian Black Backing. The Handrail and Plinth are of Rosé du Var.

of close texture, and contains small white shells. The Belgian variety is of good quality, and, as it can be produced at low cost, is in most extensive use. The principal use of black marble is for floor tiles, borders, etc., and as a backing to perforated work when fixed on walls, etc. (see Fig. 66). The material for these purposes is generally imported ready for laying. For decorative

purposes, the dado styles to grand staircase of the Holborn Restaurant, W.C., may be cited.

Blanc P.—One of the varieties of white Italian marble. Quarried at Carrara and Massa. Blanc P. resembles Statuary to some extent, being free from veining and prominent markings. It is softer than ordinary Sicilian, but harder than Statuary, for which it is occasionally substituted when lowness of cost is a consideration. Principally used for ecclesiastical work and for memorial tablets for interiors.

Bleu Belge.—A Belgian marble, having a deep black ground, with white crystalline veins running with the bed. Sometimes known as Grand Antique Belge. Sound, and obtainable in large blocks. Slabs obtained from selected blocks cut "with the bed" show a fine "figure." Used extensively for skirtings at the Holborn Restaurant, W.C., the National Gallery, etc., and for pilasters, etc., at Winchester House, Old Broad Street, E.C., the latter being a particularly fine instance.

Blue Turquin.—*See* **Dove.**

Boisjourdain.—A French fossiliferous marble, dark grey in tone, having white crystalline veins with a red tinge, and small red markings. Fairly sound. Inexpensive. Quarried near Laval, Brittany. Principally used as skirtings and dadoes, etc., in restaurants, including several of Lyons's establishments.

Brazilian Onyx.—*See* **Onyx.**

Breccia Africano.—An Italian brecciated marble of similar appearance to Brêche Violette, but rather lighter in tone. Quarried at Pietrasanta. Used in several of Lyons's restaurants.

Brêche de Dourlais.—*See* **Waulsort.**

Breccia de Seravezza.—*See* **Brêche Violette.**

Brêche Portor.—*See* **Portor.**

Brêche Rosé.—*See* **Norwegian Marbles.**

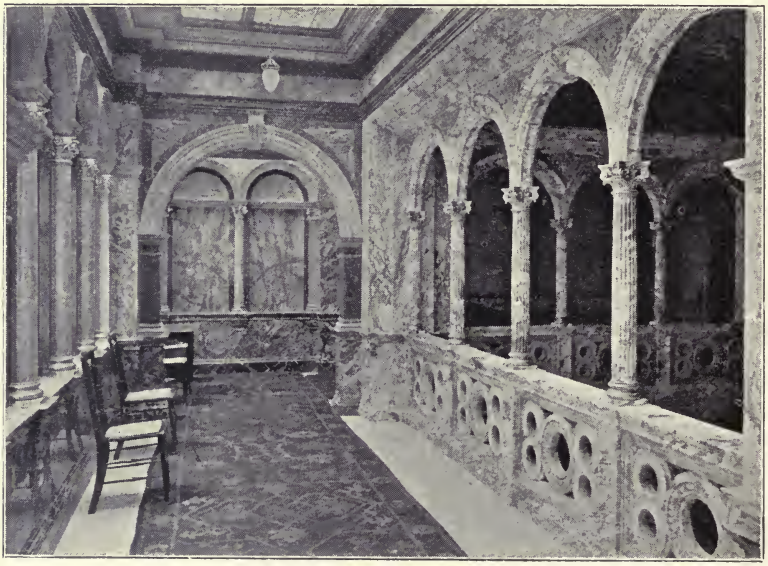
Brêche Sanguine, or Breccia Sanguina.—An Algerian brecciated marble, having a rich, deep red ground, with occasional patches of lighter shade. Quarried in the Montagne Gris, near Oran. This is the best-known of the Numidian marbles (the Marmor Numidicum of ancient Rome). Sound, and of handsome appearance. The columns in board room at Lloyd's Registry, Fenchurch Street, E.C., and skirtings, etc., at new Sessions House, E.C., are instances of its use.

Brêche Souris.—A French variegated marble, having some resemblance to Ashburton, but without the distinctive fossil markings of the latter. Quarried near Laval (Brittany). Fairly sound. Inexpensive. Used for skirtings and dado string in several of Lyons's restaurants, etc. The term "Brêche" is, in this instance, a misnomer, the marble being of the variegated class.

Brêche Violette.—An Italian brecciated marble, having a white or yellow ground, with purple, red, brown, and green markings. Principally quarried in the neighbourhood of Seravezza, and sometimes known as Breccia de Seravezza. This marble varies to a large extent, both in the colour tone and the size of the fragments embedded in the magma. Sound blocks can be obtained to any practicable size, but care must be taken in selecting the material where the colour tone is required to be kept within a reasonable degree of variation. Brêche Violette has been used for exterior work as columns to entrance of Hamilton House, Thames Embankment, E.C., also for columns and facings to pilasters at

22, Oxford Street, W. It is not suited for use in exposed positions. The colours are liable to fade, and effloresence may be expected along the lines of the cementing medium of the marble. For interiors, the balcony round first floor, etc., at the Hotel Russell, W.C., and columns in main entrance of the War Office, Westminster, S.W., may

Fig. 67.



A Marble Balcony: Brêche Violette in Profusion.

be referred to, also the panels in the new buffet at Victoria (S.E. & C.) Railway Station, S.W. (see Plate III.).

Calacata.—A variety of white Italian marble having broad veinings of a slaty grey colour. Quarried at Carrara. Sound, and opens out well for panels. The wall lining to grand staircase of Hotel Cecil, W.C., and panelling at entrance to Egypt House, Old Broad Street, E.C., are good instances of its use.

Calderano.—An Italian brecciated marble, the prevailing colour tone being a creamy pink, with grey and red cementing medium. Quarried in Calabria, Southern Italy. Sound, and taking a high polish. Of recent introduction, and not yet in extensive use.

Californian Onyx.—*See* **Onyx.**

Campan.—A distinctive name given to the French variegated marbles quarried in the Campan district, Hautes Pyrénées. These marbles may be identified by their peculiar mottled markings. The Campan marbles are generally sound, and take a good polish. The varieties in general use are :—

Campan Vert.—A light green marble, with white markings, occasionally tending to flesh colour, and white crystalline veins. Used for exterior work in pilasters to Gainsborough House, Hanover Square, W. For interiors, the columns, architraves, etc., at entrance hall of the Hotel Russell, W.C., and panel surrounds at Messrs. Dewar's offices, Haymarket, S.W., may be cited. A slightly inferior quality marble of similar appearance, containing rust-coloured markings, is sold under the name of *Vert Vert.*

Campan Melangé.—A marble of similar colour and marking to Campan Vert, but with broad chocolate bands traversing the formation. Used in the great chimney-piece in Hotel Russell entrance hall, columns in coffee-room, Hotel Great Central, etc.

Campan Rosé.—A marble of similar character to the above, the colour tone being a reddish brown, with markings of lighter shade. Used for pilasters in grand *salle à manger* at Hôtel Métropole, etc.

Note.—Difficulty is sometimes experienced in obtain-

ing blocks from the Campan district during the winter months, the quarries being at a high altitude, and the snowfalls generally heavy.

Cippolino.—A distinctive name given to laminated marbles having a talcous stratification. The varieties in general use are known as Swiss and Greek Cippolino respectively.

Swiss Cippolino is quarried at Saillon, near Saxon, in the Canton of Valais. It has a pale green ground, with straight thin veins running through the formation. The ground colour varies, and the veinings are at times very heavy. Owing to the straightness of the veins, the marble when sawn with the bed shows a fine figure. The varied effect produced by its use when sawn with and across the bed is seen to advantage in the door jambs in the interior of 22, Fenchurch Street, where this marble has been used "both ways." Instances of its use for columnar work are Electra House, Finsbury Pavement, E.C. (exterior), and the United Kingdom Provident Institution, Strand, W.C. (interior). A good illustration of the use of this marble for panelling is the Public Hall, Shoreditch Municipal Buildings, E.

Greek Cippolino is an instance of an ancient marble rediscovered. The quarries are situated on the Island of Eubœa, in the Grecian Archipelago. The marble is very sound, and obtainable to any reasonable dimensions. The colour tone is light green, with broad markings of a deeper shade, the impression conveyed by its use being a combination of richness and strength. This marble is suited for use in exposed positions, and has been employed for exterior work in Messrs. D. H. Evans's and Waring's premises in Oxford Street, W., etc.

For interiors, the new Sessions House, E.C., and the United Kingdom Provident Institution, W.C., are good instances of its use, both for columnar and flat treatment and for curved surfaces. Both Greek and Swiss Cippolino are effectively used for constructional and decorative purposes combined at the Roman Catholic Cathedral, Westminster, S.W. (see Plate II.).

Comblanchien.—A French unicoloured marble, quarried near Boulogne-sur-Mer. It has a creamy tone, is rather soft when fresh from the quarry, but hardens rapidly on exposure to the atmosphere, and will take a good polish. Used for the staircase, etc., at Frascati's Restaurant, Oxford Street, W., etc.

Connemara.—*See* **Irish Green.**

Corallo.—A Portuguese fossiliferous marble, light red in colour, without prominent markings. Quarried at Pedro Pinheiro, near Lisbon. Fairly sound, but liable to exfoliation if used where ventilation is deficient. Used as wall panelling (banded with Vedrasse) in dining-room of new Sessions House, E.C., etc.

Cork Red.—A variegated marble quarried in the south of Ireland. The colour tone varies from light red, with white mottled markings, to brown, with small red and white spots and fine red and brown veins. Also known as Victoria Red. Largely used for ecclesiastical work. The columns supporting the pulpit at St. Paul's Cathedral, and wall linings to staircases at the London Stock Exchange (1904 extension), are good instances of its use.

Dark Hopton.—*See* **Hopton-Wood.**

Derby Fossil.—A fossiliferous marble, having a dark grey ground interspersed with crinoids. Quarried at Wirksworth, Derbyshire. Sound. Used in small

panels in main corridor of Imperial Institute, Kensington, S.W., columns in chancel of Roman Catholic Church, Spanish Place, W., etc.

Dove.—A well-known Italian marble, soft grey in tone, with occasional light patches. Quarried at Carrara, Massa, and Seravezza. Sometimes known as Bleu Turquin. Principally used for flooring purposes as an alternative to black marble, also for electrical work (switchboards, etc.). Used for decorative purposes to only a small extent.

Echaillon.—A French unicoloured marble, light grey in tone. Quarried in Brittany, principally for building purposes. Used extensively for wall linings, floors, etc., at the Ritz Hotel, Piccadilly, W.

Emperor's Red.—A Portuguese fossiliferous marble of similar appearance to Corallo, but of slightly deeper shade. Quarried near Lisbon. The buffet fittings of the Norfolk Hotel, London Street, Paddington, W., may be quoted as an instance of its use.

Fleur de Pêcher.—An Italian brecciated marble, having a white ground. Similar in character to Brêche Violette, but with peach-coloured markings predominating. Difficult to obtain in large sizes. The newels to grand staircase at the Hotel Victoria, S.W., may be quoted as an instance of its use.

Frosterley.—A dark grey fossiliferous marble of handsome appearance quarried at Harehope, Co. Durham. Very hard, taking a high polish. Principally used for ecclesiastical work (see Figs. 27 and 43, also Plate IX.).

Genoa Green.—An Italian variegated marble, having a dark green ground, nearly black, with a network of fine veins of lighter shade of green, and white crystalline markings. Quarried at Pietralavezzara, near Genoa,

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PLATE XI.

GIALLO ANTICO (N. AFRICA).

ONE OF THE ANCIENT NUMIDIAN MARBLES.

[*To face p.* 199.

This marble has been in extensive use for many years, but is being superseded by Greek Tinos, the marking of which is somewhat similar, while its production is more economical. The skirtings and architraves in the National Gallery, dado of oak saloon, Hôtel Métropole, etc., are instances of its use.

Giallo Antico.—A Tunisian variegated marble of great beauty, having a rich yellow ground with a rose-pink tint and occasional deep red markings. Quarried at Chemtou, in the Medjera Valley. This marble was known to the ancient Romans and used by them to a large extent. It is sound and easily worked, and takes a brilliant polish. Sometimes known as Jaune Antique. The linings to dwarf walls at entrance stairs of the National Gallery, and the pedestal of Endymion asleep, in Third Græco-Roman Room at the British Museum, are instances of its use (see Plate XI.).

Grand Antique Belge.—*See* **Bleu Belge.**

Grand Antique Pyrenees.—A French brecciated marble of striking appearance, made up of angular fragments of black and white, showing sharp contrasts. Sound, and when used in masses has an impressive effect. The dado, etc., at grill-room of the Holborn Restaurant, W.C., and pilasters at Salisbury House (Circus Place entrance), E.C., are instances of its use.

Griotte de Caunes.—A French variegated marble, having a dark red, merging on brown, ground, with mottled markings of lighter shade and white crystalline veins. Quarried generally in Southern France (Var, Pyrénées Orientales, etc.). Principally used for small columns and reliefs to black marble clock cases. Not extensively used in Great Britain.

Griotte d'Italie.—A marble of similar appearance to Griotte de Caunes, but containing small shell markings of crystallised calcite, and having an altogether richer appearance. Sound. Quarried near Carcassone, Aude.

Fig. 68.

A Decorative Interior: Griotte de Sost and Campan Vert.

Principally used for high-class chimney-pieces and small ornaments. The supply of good quality material for other than small work is somewhat uncertain.

Griotte de Sost.—A French variegated marble, brownish-red ground and white crystalline veins. Fairly sound. Quarried generally throughout the Pyrenean

district. Used for pedestals supporting columns in entrance hall of Hotel Russell, W.C. (see Fig. 68), and for skirtings on upper floors; also for dado to King's Hall, Holborn Restaurant, W.C.

Gris Rouge. — A fossiliferous marble having a medium-toned grey ground, with red and white markings. Quarried in the Hainaut province of Belgium. Fairly sound, and inexpensive. Principally used for table-tops, etc.

Gris St. Michel.—A French variegated marble, having a medium-toned grey ground, with pronounced markings of deeper shade and thin crystalline veins. Sound, and takes a good polish. Obtainable in large sizes. Inexpensive. Used as skirtings at Bell House, 10 and 12, Copthall Avenue, E.C., etc.

Hopton-Wood.—One of the best-known of British marbles. The marbles are graded into three varieties, ranging from a creamy ground to a medium-toned grey, with crinoid fragments of lighter shade. Sound, and obtainable in large blocks. Does not take a high polish. This marble is available for constructional purposes, both exterior and interior, also as a veneering of thin slabs. The L.C.C. School of Arts and Crafts, Southampton Row, W.C., is a good instance of the former use. For the latter, the ground-floor corridors of the new Sessions House, E.C. (alternate courses of Hopton-Wood and Vedrasse) may be cited. The pedestal of the Gordon Memorial, Trafalgar Square, W., is an instance of its use for exterior work (see p. 109).

Iona.—A light green serpentinous marble of handsome appearance, quarried in the Western Hebrides. The quarries have only been systematically worked very

recently, and the marble is not yet well known. The colouring is rather more delicate than Irish Green, which it somewhat resembles. Stocks are being accumulated in anticipation of a considerable demand as the marble becomes known.

Ipplepen.—A medium-toned red marble, with grey patches and white crystalline veins. Quarried at Ipplepen, near Newton Abbot, Devonshire. Fairly sound, and takes a good polish. Used locally for building purposes, also for ecclesiastical work.

Italian Onyx.—*See* **Onyx.**

Irish Green.—A well-known serpentinous marble (ophicalcite), quarried in County Galway, Ireland. A large proportion of the output is exported to America, there being a considerable demand for this product among connoisseurs in decorative art in the United States. The Belgian demand, too, is considerable. A particularly good instance of its use is in the pedestals supporting columns in the board room at Lloyd's Registry. Material of similar quality to this is, however, difficult to obtain. Good average quality material is used in the shop front of Martin Bros., 25, Cheapside, E.C., and the chimney-piece in Hamburg-Amerika Line offices, Cockspur Street, S.W. Irish Green is a "tough" marble, and suited for high-grade marble floors.

Jaune Antique.—*See* **Giallo Antico.**

Jaune de Var.—A French medium-toned yellow marble without prominent markings. Takes a good polish and is fairly sound. Sometimes used as a substitute for pale Siena.

Jaune Lamartine.—A French variegated marble, having a rich yellow ground with a network of fine pencil

veinings of bright red colour. Quarried near Molinges, Jura. A sound marble of handsome appearance, obtainable in large blocks. Used for staircase balustrade at Hotel Cecil, W.C., dado on ground floor of Salisbury House, E.C., etc.

Jaune St. Beaume.—A marble of similar character and markings to Jaune Lamartine, but without the evenness of tone shown by the former. The wall panelling at the office of the Life Assurance Company of Australasia, 4, Cheapside, E.C., may be quoted as an instance of its use.

Joinville.—A French variegated marble, having a fawn-coloured ground, with slight red patches and markings. Quarried in the Vallée Heureuse, near Boulogne-sur-Mer. The marble can be secured to any practicable size, and is of compact texture. Largely used for constructional purposes in France. The same neighbourhood produces **Lunel,** a unicoloured brownish-grey marble, and **Lunel Fleuri,** a variety of Lunel having flowered markings of slightly deeper tone. All of these marbles are used for dadoes, etc., in several of Messrs. Lyons's restaurants. They are also used as pedestals to portrait busts in the Roman Portrait Gallery, etc., at the British Museum. The marbles of the Joinville series are sound and comparatively inexpensive.

Languedoc.—A French fossiliferous marble, bright red in colour, and with white and grey-flowered markings. Quarried in the neighbourhood of Carcassone, Aude. Rather glaring in tone. Used for pilasters in ladies' grill-room, Holborn Restaurant, W.C., etc. The stall boards of several of Messrs. Dunn's establishments in London are instances of the exterior (?) use of this marble.

Leifset Gloire.—*See* **Norwegian Marbles.**

Levanto.—An Italian serpentinous marble, the colour tone ranging from purple to red, with dark green veins. Quarried at Levanto. Rather soft in working, and liable to exfoliation if not well looked after. Used in Holborn Restaurant, W.C. (corridor at side of grill-room, Venetian

FIG. 69.

AMERICAN MARBLE FOR LONDON USE: LISTAVENNA AND SWEDISH GREEN.

room, etc.), also the side chapels of the Roman Catholic Cathedral, Westminster, S.W., etc.

Light Hopton.—*See* **Hopton-Wood.**

Listavenna.—An American variegated marble, having a pure white ground, with light green veinings. Quarried in Vermont, U.S.A. First introduced into England in 1900 for the interior decoration of the marble

hall at the Criterion Restaurant. Used with effect for wall linings at Dewar's offices, Haymarket, S.W., London and County Bank, Lombard Street, E.C., etc.

Lunel.—*See* **Joinville.**

Lunel Fleuri.—*See* **Joinville.**

Mazzano.—An Italian unicoloured marble, having a cream ground, containing a light pinkish tint and slight grey markings of a veinous nature. Quarried at Brescia. Sound, and obtainable in large sizes. The marble is supplied in two varieties—Mazzano Bianco and Mazzano Semiscura, the pink tint in the ground of the latter variety being more accentuated. Has been used for exterior constructional work at Thanet House, Fleet Street, E.C. For interiors, Thanet House and the new Public Offices, Westminster, S.W., may be cited as instances of the use of both varieties (see Plate VIII.).

Mexican Onyx.—*See* **Onyx.**

Napoléon.—One of the varieties of the Joinville series (which see), but having fine veinings of light red and brown on a ground of medium-toned grey. Used in ground-floor corridor of Holborn Restaurant, W.C., etc.

Norwegian.—A general description applied to the saccharoidal marbles quarried on the Vel Fjord, near Dunderland. There are several varieties of these marbles, their general features being a very coarse crystallisation and exceptionally hard texture, making the material difficult to work. These are the only crystalline marbles of varying colours entirely free from veins. The colouring is delicate, and is mainly a combination of rose-pink and deep green. The varieties in ordinary use are known as *Leifset Gloire* (white ground, with pink and green markings occurring in stratified form); *Sunset Rosé*

(similar to the last-named, but with pink colour tone predominating); *Brêche Rosé* (white and pink, giving a brecciated appearance); *Norge Clair* (pure white). Norwegian marble is used for the exterior facing of the Junior Constitutional Club, Piccadilly, W., and weathers well. Considerations of cost, however, render its extended use for building purposes improbable. For interiors, the columns and pilasters at 3, London Wall Buildings, E.C., and Great Central Hotel, W.C., and wall linings to Medici Room, Hotel Cecil, W.C., are instances of its use.

Nyvert.—*See* **Swedish Green.**

Onyx or Travertine.—The principal varieties of onyx marble in use in Britain are: *Algerian* (Africa), light green ground, almost white, with fine yellow veins; *Arizona* or *Yava* (United States of America), sea green ground, with brilliant red and brown markings; *Brazilian* (South America), dark green, with bright red veins; *Californian* (United States), light green, with white mottled markings and yellow veins; *Italian*, straw-coloured; *Mexican* (North America), light green, with red and yellow veins; *Wyoming* (United States), dark brown, with mottled markings of lighter shade. A bright red variety from Algeria is also obtainable. Onyx marble is largely used for clock cases, lamp stands, pedestals, and small ornaments. Instances of its use for decorative purposes are: Surrounds to mirrors, Viaduct Hotel, Holborn, E.C. (Brazilian); counter top at Black Lion public-house, Queen Victoria Street, E.C. (Mexican); wall linings, Wellington Hotel, Wellington Street, Strand, W.C. (Italian); the Trocadero Buffet (Algerian); pilasters and dado, National Provincial Bank, Aberystwyth (Yava), etc. (see Plate V.).

Pavonazzo.—An Italian variegated marble having a creamy yellow ground and deep purple veinings. Quarried at Carrara. The veinings are caused by the shrinkage on cooling of the masses of Carrara marble, the cracks occurring on the edges of the marble beds being afterwards filled with metallic oxides. It is therefore liable to fracture along the line of the veins, and requires to be cramped where necessary. Pavonazzo is only found in "pockets," and is consequently variable both in supply and quality. For instance, the heavily marked marble employed in the entrance of Indemnity House, Old Broad Street, E.C. (see Fig. 70); the wall linings at the Commercial Assurance Company's offices, Royal Exchange Buildings, E.C., and the wall lining in corridor of Basildon House, Moorgate Street, E.C., were each of them "best quality Pavonazzo" at the time the work was executed. At the time of writing this marble is very scarce and of comparatively poor quality.

Pavonazzo de Numidie.—An Algerian brecciated marble of similar appearance to Brêche Sanguine (which see), but of less richness of tone.

Pentelikon. — A well-known Greek saccharoidal marble of good weathering quality. Quarried on Mount Pentelicus, near Athens. This material is suited for most of the purposes for which white Italian (Sicilian) marble is used, and is also available for building purposes. The marble from the upper layers is of a bluish-grey colour, resembling Dove Marble (which see). A selected variety of the white marble deposits is in demand for statuary purposes. Pentelikon may be obtained in three qualities—ordinary, for use for constructional purposes; selected, for decorative purposes; and statuary, for carved work and

FIG. 70.

AN ATTRACTIVE TREATMENT: PAVONAZZO AND VERDE ANTICO.

work of the highest class. Large stocks are maintained at British and Continental centres as well as at the quarries, so that supplies are ready available. The marble erections in Oxford Street and St. James's Street, Piccadilly, W., are all of them of Pentelikon marble.

Petitor. — A general name given to the marbles quarried at Petit Tor, near Torquay. There are three well-known varieties—yellow, pink, and grey. All the varieties are in use for decorative purposes, but many of the best instances are in private mansions and not accessible. A good illustration of Petitor marble is the wall lining of the London and County Bank, New Kent Road, S.E., and the grill-room of the Throgmorton Restaurant, E.C. It has also been used at the Hearts of Oak offices, Euston Road, N.W., and for balusters at top of staircase at Lloyd's Registry, E.C.

Petworth.—A fossiliferous marble, blue-grey in tone, quarried at Petworth and at East Grinstead, Sussex. Fairly sound. Principally used for ecclesiastical work.

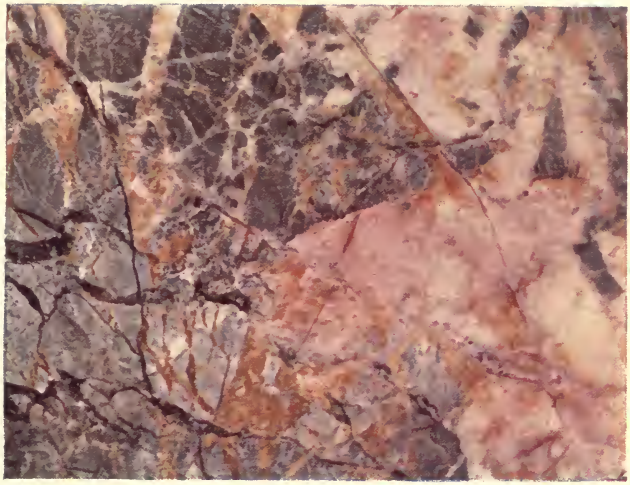
Piastraccia.—An Italian variegated marble, having a white statuary ground, with broken grey veinings traversing the formation. Quarried at Pietrasanta. Sound, but occasionally difficult to obtain, the supplies being variable. The wall linings at the National Bank of Scotland, St. Nicholas Lane, E.C., and panels in corridor of Cross Keys House, 56, Moorgate Street, E.C., are instances of its use.

Plymouth.—A distinctive name given to several varieties of fossiliferous marble quarried near Plymouth, Devonshire. The colour tones vary from grey to all shades of red, and the marbles deserve to be much better known and used. The varieties in ordinary use are

Prince Rock Grey, a fossiliferous marble, with thin red veins and white crystalline markings; *Silver Grey*, a delicate shade of grey marble, of lighter appearance than the last-named; *Plymouth Dove*, a soft-toned grey marble, with small yellow markings; *Devon Sienna*, a sound marble, having a resemblance to Jaune Antique, but of deeper ground tone; *Devon Spar*, a delicate-toned red, merging to cream colour, with a pink tinge; *Rose Red*, a coarse crystalline marble of rich red tone; *Spangled Red*, also known as *Bay Vein*, a dark grey marble, with heavy crystalline veining of various shades from bright red through pink to white; *Devon Black*, a black marble with white crystalline veins and small grey markings; another variety of this marble has heavy crystalline veining of crimson tone; *Spangled Pink*, reddish grey ground, with masses of pink crystalline markings and fine pencil veinings of brilliant red; *Favositidæ*, a handsome brown marble, highly fossiliferous; and *Clouded Yellow*, flesh-colour ground, with light yellow patches and a fine network of veins. Rose Red, Devon Spar, and Devon Sienna are only obtainable in small blocks; all the other varieties can be secured up to any reasonable size. All the varieties are in occasional use, but the marble resources of this part of the country are very much neglected. The columns at the Brompton Oratory, South Kensington, give some idea as to the availability of the Plymouth marble deposits (see Plates VI. and XII.).

Polyphant.—A close-grained, serpentinous marble, quarried in Cornwall, having a dark blue-grey ground, with small markings of lighter shade evenly distributed. Fairly sound and easily worked. Principally used for

PLATE XII.



CLOUDED YELLOW

SPANGLED RED, OR BAY VEIN

DEVONSHIRE MARBLES.

[*To face p.* 210.

ecclesiastical work. Owing to its peculiar properties (the stone is not affected by boiling in sulphuric acid), this material is in considerable demand for laboratory purposes.

Portor or Port d'Oro.—A general name given to marbles having a black ground, with yellow veins, presenting a brecciated appearance. The varieties in use are named Black and Gold, Brêche Portor, etc. The principal quarries are at Porto Venere, near Spezia, Italy. This marble is also quarried at several places in Southern France. The columns and pilasters at the London Wall Buildings, E.C., and banded treatment at the Baltic, St. Mary Axe, E.C., are good instances of its use.

Princess Blue.—*See* **Alomite.**

Purbeck. – A fossiliferous marble quarried near Swanage, Dorset. Blue-grey in tone, with calcite filling to a shell formation. One of the oldest known British marbles. Principally used for ecclesiastical work.

Red Ogwell.—A fossiliferous marble of bright red colour and large calcite fillings to fossil remains. Quarried near Newton Abbot, Devonshire. Fairly sound, but requires careful selection. Used for pilasters on staircase at Lloyd's Registry, E.C., etc.

Rhondona.—An Italian brecciated marble of handsome appearance, the colour of the fragments composing it varying from white to bright green, and pink to deep purple. Quarried in the neighbourhood of Pietrasanta. Sometimes known as Brêche Rhondoné. The pilasters on first-floor level of grand staircase, Hotel Victoria, S.W., are worked from this marble.

Ringborg Green.—*See* **Swedish Green.**

Rosé Brocatelle de Centro.—A selected variety of Verona Red (which see), having bands of deeper shade

than the ground of the marble traversing the formation. Sound, and obtainable in large sizes, but subject to the same disadvantages as Verona Red. The King's Hall, Holborn Restaurant, W.C., is a good illustration of its use.

Rosé de Numidie.—A marble of similar appearance to Giallo Antico (which see), but of slightly less delicacy of tone. Quarried in the Montagne Grise (Algiers). Used

Fig. 71.

A Staircase Landing: Rosé du Var and Siena.

in the Chapel of the Blessed Sacrament, Westminster Cathedral, S.W.

Rosé Eujugeraie.—*See* **Sarancolin de l'Ouest.**

Rosé du Var.—A French (Pyrenean) brecciated marble of bright red colour with yellow patches, giving a rich decorative effect. Sometimes known as Rouge Jaspe. While the appearance of this marble is very handsome, the surface requires frequent attention, otherwise exfolia-

tion will take place. In cases where this cannot be provided for, it is advisable for another marble to be substituted. The interior decoration of the Hotel Russell, W.C., is an instance of its use. It has also been extensively used in Lyons's restaurants.

Rosso Antico.—Considerable confusion has prevailed respecting this marble on account of the products of modern quarries in Southern France and Italy being so named. The true Rosso Antico, the Ægyptum of ancient Rome, is of Grecian origin. Its colour is deep red, with occasional white markings and white crystalline veins. The most extensive deposits are at Mani (Laconia). It is also quarried at Lageïa (Thessaly). This marble is seldom used for public buildings, its high price making it prohibitive for other than the best class of work. The frieze backing of the reredos at St. Paul's Cathedral is executed in this marble.

Rouge.—A distinctive name given to red marbles, but specially applied to the red fossiliferous marbles of Belgium. These are sold under high-sounding names—Rouge Royal, Rouge Imperial, Rouge Byzantine, Rouge Griotte, etc.; but with the exception of Rouge de Rance (which see), any and all of these varieties are ordinarily known as "Rouge," and understood to be Belgian marble, available for purposes of utility, sanitary work, table-tops, etc., rather than for decorative effect. Rouge marble often contains a number of clay veins, which are raked out and filled with stopping. An ordinary examination will not always reveal this, and the defect is only apparent after the marble is in position. Carefully selected material can, however, be used to advantage, as may be seen in the dado of grand staircase, Holborn Restaurant, W.C.,

entrance lounge, Hôtel Métropole, S.W., entrance to Tooth's Galleries, Haymarket, etc. An instance of its weathering on exposure can be found in the small columns at entrance of the *Sheffield Telegraph* building, Fleet Street, E.C.

Rouge Acajou.—A French variegated marble of medium-toned red, having a mottled marking of lighter shade throughout the formation. Quarried at Cierp (Haute Gironde). Sound, and obtainable in large blocks. Used for dado and panel styles in several of Lyons's restaurants.

Rouge Antique.—A marble having some resemblance to Rosso Antico (which see), quarried at Cierp and near Villerembert (Haute Gironde). Principally used for clock cases and for small ornaments.

Rouge de Rance.—A Belgian fossiliferous marble having a reddish-brown ground and large white markings, presenting a handsome though rather massive effect. Quarried at Rance (Hainaut). The quarry was reopened in 1900 after nearly 200 years of disuse, one of the first extractions of marble being material for 120 monolith columns, each 12 ft. in length, for Antwerp Railway Station. The marble is very sound, and should be available for exterior work. It is obtainable to any reasonable dimensions. The writer has no information respecting its use as yet in public buildings in this country. It has, however, been used for private house interiors, and has given great satisfaction.

Rouge Jaspe.—*See* **Rosé du Var.**

St. Anne's.—One of the best-known varieties of Belgian marbles. Very sound. Fossiliferous, with dark grey ground and light grey and white markings. The principal quarries are at Gougnies, near Charleroi.

St. Béat.—A French saccharoidal marble, free from pronounced markings, quarried at St. Béat (Haute Gironde). The crystallisation is somewhat coarser than Italian Statuary. A selected variety of this marble is held in high repute among French sculptors, some of whom prefer it to Italian Statuary.

St. Just.—An Austrian unicoloured marble of creamy tone, quarried near Trieste. Close texture, and carves and polishes well. Principally used for ecclesiastical work. The carved panels in the frieze at St. George's Hall, Liverpool, are executed in this material.

St. Katherine's.—A variegated Spanish marble of recent introduction. Reddish brown in colour, with red and fine white markings, presenting a handsome appearance. Rather soft in working, and disposed to break away on the edges. Takes a fine polish. Not yet in extensive use.

St. Sylvestre.—A variegated Portuguese marble, having a flesh-coloured ground, the surface being interlaced with red and pink veinings and broad white crystalline veins. Sound, and obtainable in large sizes. Easily worked, taking a good polish. The dado at 3, London Wall Buildings, E.C., is an instance of its use.

Sarancolin de l'Ouest.—A French variegated marble, having a yellow ground, with pink and flesh-coloured markings and occasional white veins. Quarried at Greez-en-Bauëre (Mayenne). Fairly sound, and takes a good polish. Used for wall linings in upper courses of entrance to Canadian Pacific Railway Company's offices, Cockspur Street, S.W., etc.

Sarancolin Pyrenees.—A marble of somewhat similar appearance to the last-named, but of greater

brilliance of colour. Quarried at Ilhet, near Bagnères-de-Bigorre (Hautes Pyrénées). Sound, and obtainable in large blocks. Used for wall lining and pilasters in dining-room of Hotel Russell, W.C.

Sicilian.—The term generally used for the ordinary varieties of white Italian marble. The name is peculiar to the British trade, and has become recognised from custom. The material is generally known, and needs no description. Varieties containing a bluish tinge are the hardest, and most suitable for steps and landings. The dead white varieties are generally softer, and while suited for many of the purposes for which marble is used, will not stand hard wear. Sicilian marble is quarried generally in the Apuan Alps, the principal centres being Carrara, Massa, and Seravezza, the marble being shipped *viâ* Leghorn. Quarries have also been opened in the Equi valley, on the northern slopes of the range, shipments being made *viâ* Spezia.

Siena.—An Italian variegated marble having a yellow ground with deep purple veins. Quarried at Siena and Montarenti. The quality of the marble varies to a considerable extent, and the price fluctuates considerably. A variety without distinctive veinings, the ground colour being of a lighter tint, is known as Pale Siena. Used in chimney-piece of Canadian Pacific Railway offices, Cockspur Street, S.W., also as surrounds to panels at Salisbury House, E.C.

Skyros.—A descriptive name for the marbles quarried in the Island of Skyros, in the Ægean Sea. While the ground of the Skyros marbles is generally of a creamy tint, the markings vary considerably. The blocks obtained are graded into four varieties, known as Skyros 12, 14A, 14C,

FIG. 72.

A SAGRO VALLEY (CARRARA) QUARRY.

The marble for the Queen Victoria Memorial, facing Buckingham Palace, was obtained from this locality.

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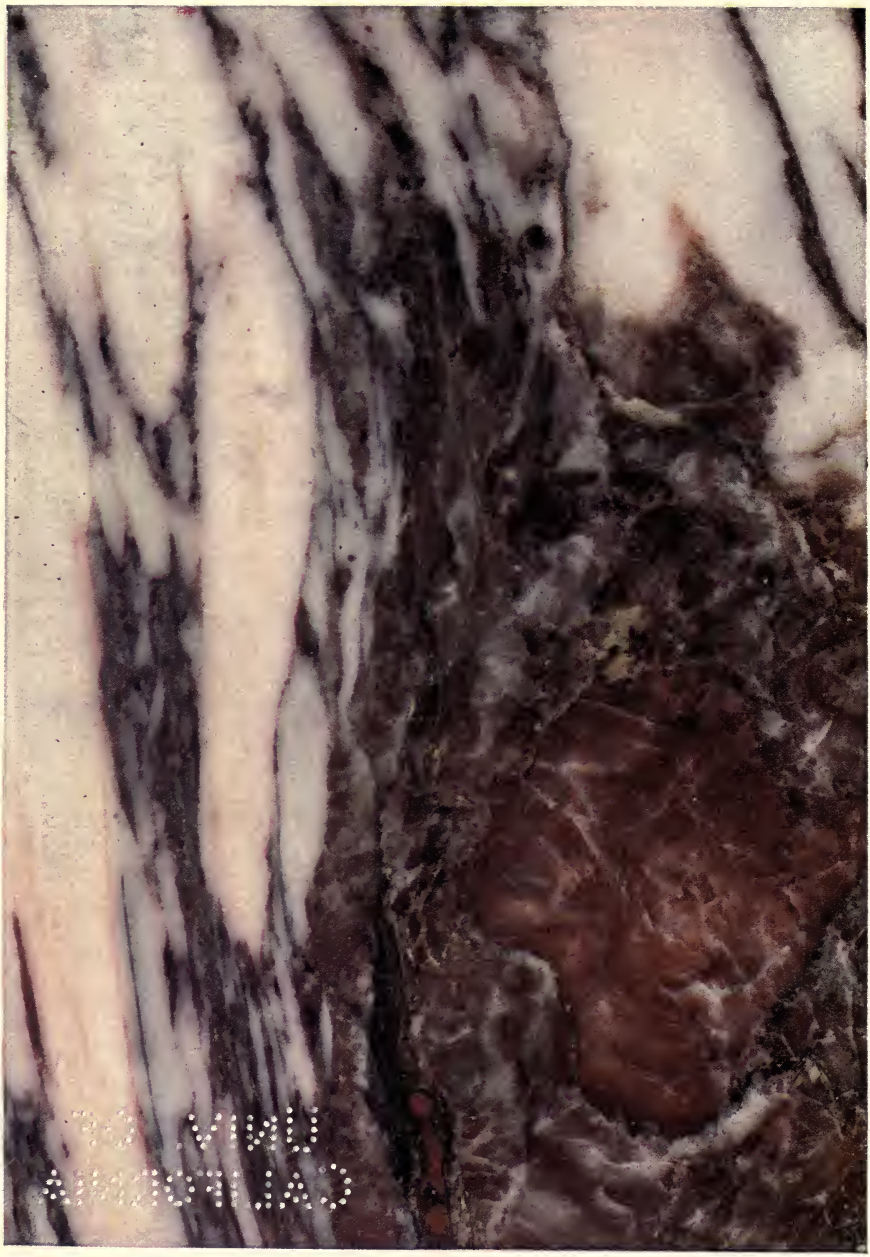

SKYROS No. 14c (GRECIAN ARCHIPELAGO).

[*To face p.* 217.

and 14E. The Skyros marbles are mostly sound, and the varieties present harmonious contrasts when used together. *Skyros* 12 is crowded with what may be described as a double network of fine veins, the colouring being pale yellow and violet. *Skyros* 14A has a rich orange-coloured marking of brecciated appearance, the markings blending with the ground in an effective manner. *Skyros* 14C is a brecciated marble of even tone, the cementing medium being of deep reddish-brown hue. This variety is less sound than the others. *Skyros* 14E is the most brilliant of all. The colouring matter is diffused, and has tinted the crystals as they formed during the metamorphic process the marble has undergone. The result is a gorgeous mass of colouring from crimson to brown, with an appearance of translucency unapproached in any other decorative medium. Skyros 14A is used for wall lining to the Manchester and Liverpool District Banking Company's offices, 75, Cornhill, E.C. A combination of Skyros 14C and 14E can be seen at Lyons's Café, 2, Newgate Street, E.C., and Skyros 14A (surrounds to frieze), C (wall lining to interior), and E (lower courses of lobby panelling) at the Canadian Pacific Railway Company's offices, Cockspur Street, S.W. (see Plates I., IV., and XIII.).

Spanish Brocatelle.—A shell marble of brilliant appearance, quarried near Tortosa (Catalonia). The ground is deep red, and is almost covered with small yellow, grey, and white crystals. Suitable for inlays rather than for large masses. Sometimes employed for small panels inset in chimney-pieces and for mountings for clock cases.

Spanish White.—A saccharoidal marble quarried in the Sierra Felabres, near Albanchez (Almeria). The crystallisation is coarser than that of Italian or Greek

marbles, and the material is rather hard. Takes a good polish and is free from veins. The quarries have only been worked extensively since 1905, and the greater part of the output has been engaged for building purposes in leading Spanish cities, so that little of the material has yet reached this country.

Statuary.—A general name given to pure white marble, free from markings, but generally understood as meaning the best quality of Italian white marble. The principal supplies are obtained from Carrara, Massa, and Seravezza, the Mont Altissimo variety from the latter locality being the more highly esteemed. A selected variety of Greek Pentelikon is used for statuary purposes, as is the French marble known as St. Béat. Owing to the difficulties attendant on selection, best statuary always commands a high price. On this account statuary marble is only in occasional use for decorative purposes. A good instance of such use is the entrance vestibule and staircase at Lyons's Popular Restaurant, Piccadilly, W.

Statuary (Second or Bastard).—The term applied to statuary marble containing blemishes, rendering it unsuitable for finest quality carved work. Available for decorative interiors, good-class chimney-pieces, ecclesiastical work, etc. The variation in quality is considerable, and where a particular effect is desired, it is advisable to secure samples showing the character of the marble to be supplied.

Statuary Vein.—White Italian marble having a statuary ground and fine blue veins traversing the formation. Available for decorative interiors, but not in great demand.

Sunset Rosé.—*See* **Norwegian Marbles.**

Swedish Green (also known as Nyvert and Ringborg Green).—A variegated dolomitic marble quarried at Norrköping (Sweden). Light sage green in tone, with white markings. Very close texture. The marble may be graded into three varieties—plain, mottled, and flowered. The plain variety has the white markings distributed in even lines, showing an apparent stratification, the mottled variety has white mottled markings evenly distributed throughout, and the flowered variety has dark green finely figured bands traversing the formation. Instances of its use are (plain and mottled varieties) pilasters at Shoreditch Municipal Buildings, wall lining at entrance of the Coliseum, W.C., etc. The flowered variety is used as surrounds to Calacata panels in the entrance to Egypt House, New Broad Street, E.C. The banded treatment at Messrs. Dewar's main office, Haymarket, S.W. (see Fig. 65), is executed in Swedish Green. It is also used for exterior work at the new Egyptian Hall, Piccadilly, W.

Tinos.—A well-known Greek marble quarried on the island whence it takes its name The colour tone is dark green, thickly covered with an extremely close network of veins of various shades of the same colour. Another variety from the same locality has a deep purple ground, with light and dark green veins traversing the formation. Both varieties are sound, the former being the closer in texture, and blocks can be obtained to any desired dimension. The fine-veined variety has been used for exterior work—large columns at Messrs. Debenham's, Wigmore Street, W., boxed up in pilasters at No. 3, Cheapside, E.C., also for shop front, etc., at 6–7, Poultry, E.C. Both varieties are used at the new Sessions

House, E.C., the columns on either side of recesses in ground-floor corridor having a purple ground, while the pilasters adjoining are of the fine-veined material.

Vedrasse.—A Portuguese fossiliferous marble, having a creamy ground with a pink tint. Quarried at Pedro Furando, near Lisbon. Sound and easily worked, and takes a good polish. Inexpensive. Another variety of this marble has a ground of rather deeper tone, with small brown veinous markings evenly distributed through the formation. Both varieties are used in the ground-floor corridors of the new Sessions House, E.C. (banded with Hopton-Wood), and dining-room at end of corridor (banded with Corallo).

Vein.—An Italian white marble with clear ground and prominent vein markings. Largely used for decorative purposes on the Continent, but not in great demand in this country. The balcony of the Grand Salon, Holborn Restaurant, W.C., is a good instance of the decorative effect produced by its use.

Verde Antico.—A Greek brecciated serpentine of great beauty, made up of angular fragments of light and dark green serpentines and pure white marble. The colouring matter has penetrated the white fragments during the process of cooling down, giving the marble its distinctive markings. The material is obtained from the quarries worked by the ancient Romans near Larissa (Thessaly). The ancient workings were rediscovered by Mr. W. Brindley, F.G.S., in 1886, and the marble has been largely used of recent years. It is one of the soundest of breccias, and is obtainable in large-sized blocks. The material is ordinarily supplied as light, medium, or dark Verde Antico, the medium-toned variety

being in most general use. This marble is used for exterior work, banded with Portland stone, at the Gaiety Theatre, Strand, W.C. Recent instances of its use for interiors are columns in Roman Catholic Cathedral, Westminster, S.W., and new Sessions House, E.C., pilasters, etc., at Æolian Hall, New Bond Street, W., etc. The light variety is used in wall lining at entrance of Friars House, New Broad Street, E.C., also for window fittings in the "J.P." restaurants in various parts of London.

Verde de Prato.—An Italian serpentinous marble of dark green tone, with small mottled markings of lighter shade. Quarried at Prato (Tuscany). Soft, and only obtainable in small blocks. Principally used for bust pedestals, etc. This material must be employed with discretion, as it is liable to deterioration if exposed to changes of temperature. The skirtings at the Savoy Hotel and lining at back of the reredos at St. Paul's Cathedral are instances of its use for decorative purposes.

Vert Vert.—*See* **Campan Vert.**

Verona Red. — An Italian fossiliferous marble quarried near Verona. Brick red in colour, with small markings of lighter tone. Requires careful attention, being liable to exfoliation. A selected variety of this marble, with bands of darker hue running through the formation, is known as Rosé Brocatelle de Centro. The King's Hall, Holborn Restaurant, W.C., and balustrading at New York Mutual Life offices, Cornhill, E.C., are instances of the use of both varieties.

Verona Yellow. — A Verona marble of similar character and formation to the last-named, but with a yellow tone. The chimney-piece in the entrance

lounge, Hotel Victoria, S.W., and wall panelling in grand staircase of the new Sessions House, E.C., are instances of its use. The columns supporting the baldachino at Westminster Cathedral, S.W., are executed in this marble.

Vert des Alpes.—An Italian serpentinous marble of similar appearance to Genoa Green (which see), but slightly deeper in tone. Quarried at various localities in the Cottian Alps. Fairly sound, and free working. The skirtings to entrance hall, etc., of Hotel Russell (ground floor) is an instance of its use.

Vert d'Eau (also known as Vert d'Estoure).—A French variegated marble of similar appearance and colour to Campan Vert, but rather closer in texture. Quarried at Estoure (Ariège). Obtainable in large sizes. Used at the Alliance Assurance Company's offices, Bartholomew's Close, E.C. ; surrounds to Piastraccia panels at Cross Keys House, 56, Moorgate Street, E.C., etc.

Victoria Red.—*See* **Cork Red.**

Waulsort.—A Belgian brecciated marble, made up of angular fragments of black, various shades of brown, red, grey, and white marbles cemented together. The prevailing colour tone is dark brown. Quarried at Hastières, near Dinant. Also known as Brêche de Dourlais. Very sound for a brecciated marble. Used for a dado at crush room adjoining Roman atrium, Hotel Cecil, W.C. ; panel surrounds in corridor of Winchester House, E.C., etc.

Wyoming Onyx.—*See* **Onyx.**

Yava Onyx.—*See* **Onyx.**

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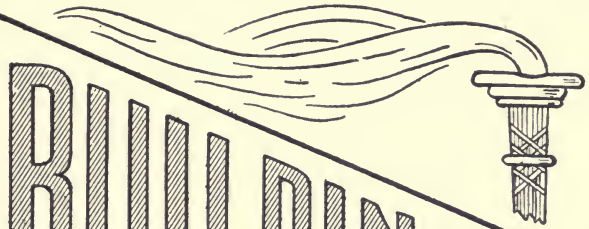

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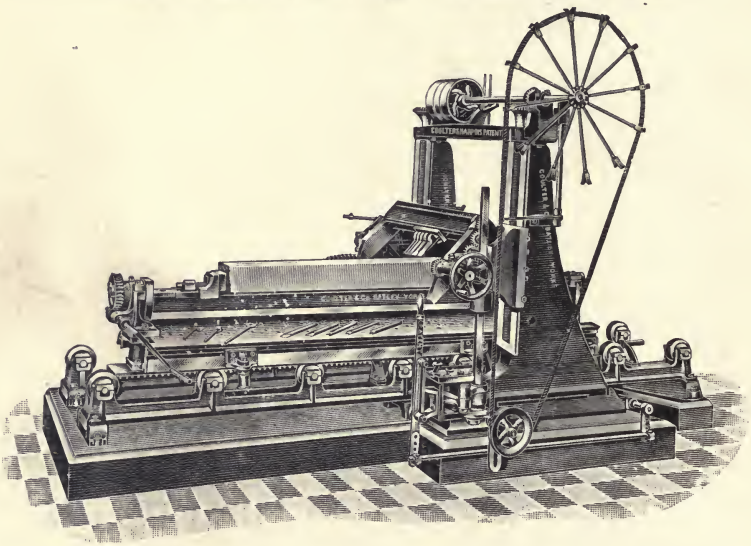

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